NATIONAL AGRICULTURAL RESEARCH & EXTENSION INSTITUTE

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EXECUTIVE SUMMARY

In 2015, the programmes/projects/activities undertaken by the Institute were in consonance with the Institute's Strategic Research & Development Agenda (2013-2020) as well as the National Strategy for Agriculture in Guyana (2013-2020). Emphasis was also placed on green agricultural practices (integrated pest management, vermicomposting, national tree planting exercises and uses of lures, biochar, biostimulants and rhizobia). Technology transfer, farmers' training and the provision of quarantine services were also integral components of the activities undertaken by the Institute in 2015.

A status report on the implementation of the various programmes/projects/activities is shown in Appendix 1. The work programme of the Institute was executed at the various locations shown on the map on Appendix 2.

A. Enhancing Agricultural Diversification

A number of initiatives were undertaken to enhance agricultural diversification. These included the development of agronomic packages for new sweet pepper varieties, cultivation of spices, soybean, carrots, red onions and the acquisition of a new sweet potato variety as well as Black Sigatoka Disease resistant plantain varieties.

Agronomic packages were developed for three new sweet pepper varieties (Goliath, King Arthur and Marconi). These were varieties which were recently introduced into Guyana which had market acceptance. Studies were conducted in both open field and shaded conditions. In all cases, yields were significantly greater under shaded conditions. Fertilizer packages were disseminated for use by farmers. The maximum yields obtained for Goliath, King Arthur and Marconi were 50,725 kg/ha, 52,335 kg/ha and 48,600 kg/ha, respectively.

Turmeric, ginger and black pepper were the spices targeted in 2015. In Region 1, 28 farmers were provided with 22,000 lbs of turmeric to expand cultivation. Two acres of black pepper were monitored in Region 1 as these were now in the production stages. Black pepper seedling (1200) were produced for distribution to farmers. There was approximately 100 acres of ginger under cultivation in Region1 which was continuously monitored by field officers.

With respect to soybean, seed material for the Trecaja variety was maintained both at Mon Repos and Ebini. The proposed expansion of cultivation did not materialize in 2015. Discussions were ongoing with a private investor on the expansion of soybean cultivation in the Intermediate Savannahs. At the end of 2015, the said investors had begun mobilization of equipment, etc. with the intent of establishing a facility at Kimbia to undertake soybean cultivation.

Work was ongoing on the production of red onions and carrots. The various parameters for these crops were established. Establishment of these crops on farmers' fields would be conducted in 2016.

A new sweet potato variety (Beauregard) was acquired from Jamaica. The 6383 slips were planted at Mon Repos. These clean planting materials would be used for expansion of cultivation. Harvesting would be done in the first quarter of 2016.

Black Sigatoka Disease (BSD) resistant plantain varieties were acquired from CARDI. These materials were being multiplied in the tissue culture laboratory for field planting in the second half of 2016.

B. Greener Agricultural Practices

Greener Agricultural Practices that were promoted in 2015 included Integrated Pest Management (IPM), vermicomposting, use of pheromone (lures), biostimulants and rhizobia and biochar and the national tree planting exercise. Additionally, a booklet was produced on greener agricultural practices.

IPM studies were executed on the management of BSD on plantains, and on red palm mite (RPM) on coconuts. In the case of BSD, evaluation of the different sanitation practices used along with plant nutrition, weed control, monitoring of pests and diseases, disease severity and fungicide usage were conducted.

Overall, the treatments using the different sanitation practices had the highest and healthiest number of leaves as compared to the control. There were no significant differences in treatments in terms of disease infection rate and bunch weight. Sanitation practices of any form are a major component in managing the disease. Prior to the implementation of Integrated Pest Management (IPM), farmer obtained an average bunch weight of 25-30 lbs. /plant. The use and monitoring of this IPM system approach has increased bunch weight to an average of 40-41lbs. /plant.

Studies were initiated on the use of predators to manage RPM. The predatory mite used was Amblyseius spp. Results obtained from this experiment revealed that during the 24 hour period one female amblyseius spp consumed a total of 10 eggs, 7 nymphs' two adults whilst no males were consumed. Results of this study support the proposition that A. spp is an important mortality factor of R. indica and should be considered as a key biological control agent and should be included in an Integrated Pest Management Strategy.

Further, it should be pointed out that the available organic pesticides (Aramite, Bemix and Kampat) on RPM population on coconut palms had no effects in controlling Red Palm Mite.

The utilization of pheromones (lures) continued to be promoted for the management of pests of economic importance. These include lures to control diamond back moth in cabbage and pheromones traps for controlling sweet potato weevil. This latter technology is currently employed by sweet potato farmers. The Carambola Fruit Fly

(CFF) was also being managed through three use of pheromone traps in the various regions.

Promoting the use of rhizobia in legume (bora, minica iv) was an on-going exercise. More farmers are now aware of the importance of using this inoculum in legume production. Field demonstrations and training were provided to a number of farmers.

The use of biostimulants (Evergreen, Bountiful harvest and Cytokin) was utilized in studies on cassava to increase production/productivity. The application rate of (10 mL/3.8L H2O) was applied by foliar spraying in three applications. The experiment was arranged in a completely randomized design, with eight treatments and two repetitions. The tuber yield significantly increased with the different biostimulants applications, with a 30%, increase using the Evergreen when compared with the control. The total Shoot weight, Plant height and Canopy thickness showed maximum values when treated with Evergreen. The development of tubers length and diameter were significantly increased when treated with Evergreen and Bountiful harvest respectively.

The use of biochar as a soil amendment has received attention due to its potential to improve physical and chemical soil properties as well as contributing towards soil carbon sequestration. An experiment was carried under shade house conditions at Mon Repos to study the effects of biochar made from rice husk and its potential as a soil amendment on Tabela sand. Application of biochar increased soil pH, organic matter content, soil water holding capacity, exchangeable cations, nitrogen, phosphorous, cation exchange capacity and decreased bulk density and iron concentration. There was a 32.81 % increase in biomass using 25 t/ha application rate in the first crop cycle compared to the control. However, plant biomass was significantly reduced for all treatments, and for every parameter measured in the second crop cycle indicating that biochar is not a fertilizer. The results of this study suggest that the beneficial effects of rice husk biochar did not last beyond one crop cycle. The results showed that the application of rice husk biochar can be used to improve soil quality of marginal soils in Guyana and make sustainable use of available rice husk.

C. Farming Systems and Techniques

The utilization of the biotechnology laboratory, shaded cultivation, macro propagation and promoting mechanized systems for planting and harvesting cassava were given prominence.

A micropropagation protocol for two crops (Pineapple and Sweet potato) is in the process of being completed. Optimistic results have been gained in other crops (Cassava, Plantain & Bananas and Coconut). The almost completed protocols are in a refining state and need to be tested in other varieties to ensure the effectiveness in a wide range of accessions (e.g. the pineapple protocol was completed only with Sugar loaf pine, but is unknown it effectiveness in Smooth cayenne or Tiger head pineapples).

With the idea of protecting our native plant genetic germplasm and having it readily available for use in a given time, the in vitro conservation techniques offer a secure tool in achieving this goal. In this regard, a local germplasm collection of some of the most important crops was initiated in 2015. Twelve different accessions of cassava, eight accessions of plantain and bananas, five accessions for Sweet potato, three accessions for pineapple and eight accessions of coconut palms not clearly identify (18-months, 3 years, 5 years and dwarf nuts green and yellow) were collected.

A study was conducted to examine the effects of plant growth hormones on enhancing production of macropropagated plantain plantlets. The hormones used were benzyl aminopurine, giberellic acid and cytokin. Results showed that corms treated with benzylaminopurine had an average of 16 plantlets, corms treated with gibberellic acid had an average of 5 plantlets, corms treated with cytokinin had an average of 6 plantlets and corms with no treatment had an average of 13 plantlets. Plantain corms treated with benzylaminopurine also showed earliness in the days for growth, days for growth after reactivation and days until emergence of fifth plantlet from planting. Great potential was

seen from this treatment because it can multiply more plantain seedlings using less planting material in a shorter time span.

A hydroponic facility was established at Mon Repos in collaboration with the Organization of the American States (OAS). It was being used for training and demonstration purposes. The facility was fully operational towards the end of 2015. Costs of production studies for some adaptable crop types would be conducted in 2016.

A cassava planter as well as a harvester was acquired through the regional cassava project. The planter was utilized to plant three acres of cassava at Kairuni. The harvester would be utilized during the first quarter of 2016. These implements are intended for use in commercial operations which would commence in 2016.

A high tunnel station was established at the Tain Campus, Berbice. It was fully operationalized in November 2016. The facility would be utilized for research, training and demonstration purposes both for staff and students as well as the farming community.

D. Crop Statistics, Data Collection and Training

Data collection on crop production was done on a monthly basis and presented to the Ministry of Agriculture on a quarterly basis. Crop production data for selected communities for 2015 is shown in Appendix 3. There were significant increases in the production of dried coconuts, plantains, pumpkins and peppers compared to previous years. The detailed crop production data for 2015 is shown in Appendix 4.

E. Agroenergy

Two projects were successfully executed with respect to agro-energy. One dealt with assessment of water quality emanating from the Bio-ethanol Plant at Albion and the other on the evaluation of vinasse and vermicompost as amendments for cash crop

production. With respect to the former, 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 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 plant 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. In addition, magnesium and manganese indicated an increasing trend with time and a decreasing trend with distance and may be sourced to the vinasse.

For the latter, results indicated that vinasse and vermicompost could be utilized as organic replacement for inorganic fertilizers in pak choi production.

E. Mangrove Management/Restoration

Mangrove restoration activities completed during 2015 focused on alternative restoration interventions i.e. the use of Spartina grass and coastal infrastructure as interventions to promote and encourage sedimentation and natural regeneration. An assessment of the status of coastal mangroves forests completed early 2015 indicated that there were limited sites available with suitable conditions to support mangrove restoration through seedlings planting.

The Spartina grass planting project was completed in collaboration with GUYWID as part of the implementation of the Community Led Mangrove Restoration Project.

Spartina grass planting was conducted during the period February 18, 2015 to June 19, 2015. Eight thousand and thirty eight (8,038) shoots/plugs of grass were planted at locations in Region #2 and Region #4 across five sites in an area measuring a total of 950m in length.

Coastal engineering interventions executed during 2015 included the construction of a brushwood groyne at Walton Hall and repairs to existing structures. The Walton Hall Bamboo Brushwood dam was completed as the first phase of a two phase project complete a groyne field at the site. The design of the structure will promote sediment accretion and consolidation thus creating an environment suitable for mangroves to colonize. Construction of the 100 meter Walton Hall Brushwood Dam was awarded to Samaroo's Investment following a competitive bidding process and was completed on the 20th December, 2015.

Repairs and maintenance works were completed on the Buxton Brushwood groyne field and the Victoria Geo-tube breakwater. Works completed on the Victoria Geo-tube groyne included, replacing five fill ports, patching long tears due to extensive abrasion with a combination of materials. Repairs to the Buxton Brushwood dam were completed with support from the Community Led Mangrove Restoration Project and included, replacement of vertical bamboo piles spaced at a minimum distance of 0.5meter apart and repairs to the bamboo fences beginning with the westernmost T-shaped groyne working from the long shore section cross-shore fence followed by breakwater (head of groyne). The three T-Shape fences were revamped at the Buxton foreshore.

F. Quarantine Service

The NPPO has made tremendous strides in improving the delivery of quarantine services at the various ports of entry, wharves, terminals and warehouses. This is evident in the forty-two (42) and eight (8) percent increases in import and export inspections conducted respectively over the previous year 2014.

The NPPO continues to supervise the quarantine treatment of agricultural commodities prior to export to ensure compliance with trading partners Phytosanitary requirements for trade. In this regards, the fumigation of rice and rice products in collaboration with the Guyana Rice Development Board (GRDB), exporters and millers was given high priority as Guyana continued with its rice export expansion activities. Aircrafts and ships entering Guyana's territorial land and water space were all subjected to inspection and approval process applied.

During the reporting period, efforts aimed at strengthening our pest surveillance and surveys programmes were intensified. The NPPO worked proactively to reduce risk associated with exotic pests and diseases introductions; shared information and communicated responsibilities for effective pest exclusions and management and collaborated with other agencies to safeguard Guyana's food supply and plant resources from external threats.

G. Publications

There were two International Publications in 2015.

1. *Abrahim, B. N., Clementson, C. & Homenauth, O. (2015) '**An investigation of the potential impacts on air quality during operations of the Bioethanol Demonstration Plant in Albion, Berbice'**: Global Scholastic Research Journal of Multidisciplinary ISSN: 2349-9397: 1.13.*

2. *Cumberbatch, R. N., Homenauth, O., (et al) (2015) '**A Protocol for the Planting, Managing and Cost of Establishing a Fruit Orchard in the Intermediate Savannahs of Guyana'**: Global Scholastic Research Journal of Multidisciplinary ISSN: 2349-9397. Issue 12.*

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1.0 ABSTRACTS OF COMPLETED RESEARCH PROJECTS

(i) Effect of Rice Husk Biochar as an Amendment on a Marginal Soil in Guyana

Tracy Persaud[1], Dr. Oudho Homenauth[1], David Fredericks[1] and Seon Hamer[2]
NAREI[1] and University of Guyana[2]

The use of biochar as a soil amendment has received attention due to its potential to improve physical and chemical soil properties as well as contributing towards soil carbon sequestration. An experiment was carried under shade house conditions at Mon Repos to study the effects of biochar made from rice husk and its potential as a soil amendment on Tabela sand. Biochar was produced by slow pyrolysis; after which it was applied as a soil amendment for the cultivation of two crop cycles of Pak Choy. Rice husk biochar was applied at rates of 0, 5, 25, and 50 t/ha in combination with inorganic fertilizers. Application of biochar increased soil pH, organic matter content, soil water holding capacity, exchangeable cations, nitrogen, phosphorous, cation exchange capacity and decreased bulk density and iron concentration. There was a 32.81 % increase in biomass using 25 t/ha application rate in the first crop cycle compared to the control. However, plant biomass was significantly reduced for all treatments, and for every parameter measured in the second crop cycle indicating that biochar is not a fertilizer. The results of this study suggest that the beneficial effects of rice husk biochar did not last beyond one crop cycle. The results showed that the application of rice husk biochar can be used to improve soil quality of marginal soils in Guyana and make sustainable use of available rice husk.

Key Words*: Biochar, Rice Husk, Soil Amendment, Tabela Sand.*

(ii) Observation Trial for Onion (Allium cepa) Under Shade House Conditions

David B. Fredericks and Tracy Persaud,
NAREI

Onion has been identified as one of the exotic crops to be grown in Region 8 as part of the Agricultural Diversification Programme. This region has favourable temperature regimes (average < 25oC) and day length (< 12 hours), which enhances bulb formation. Red Creole variety of onions were successfully grown on Kasarama Loamy Sand under shade house conditions at Mon Repos. Onion seedlings were transplanted 28 days after planting and fertilizers applied at 50-100-50 kg/ha 2, 21 and 42 days after transplanting. It takes approximately 49 days to achieve uniform bulb formation and 100 days to harvest. There were no incidence of pests and diseases. The average fresh weight of bulbs is 162.7 g and after drying reduced to 67 g. Post-harvest techniques involved curing which takes approximately 45 days or until the leaves are fully dried. The production potential of the Red Creole Variety onions is approximately 11,911 kg/ha.

***Key Works**: Red Creole variety, Kasarama Loamy Sand*

(iii) Effect of predaceous Phytoseiidae (Amblyseius sp) on RAOIELLA INDICA Hirst population

A. Skeete,T. Estwick & A. Churaman

NAREI

Raoiella indica Hirst is a recent invasive phytophagous mite and a pest of coconut and other species of palms species that feeds through the stomata of the host plant. Amblyseius spp (Acari: Phytoseiidae), is a predatory mite found associated with R. indica populations in different parts of the world. Amblyseius spp were reared in the laboratory for a period of two months prior to the commencement of this project. Adult Amblyseius spp were then separated from rearing arenas and placed on coconut leaf discs containing Red Palm mite and left for 24

hours after which adult female mites began to lay eggs. The life cycle of Amblyseius spp took approximately a total period from egg deposition to adulthood of eight to 11 days while the females reproduce approximately nine to fifteen eggs within its life cycle at a rate of 1 to 3 eggs/ day. To assess the feeding habit of A. spp a total of 40 red palm mites (10 female, 10 male, 10 nymph and 10 eggs) were placed on leaf disc of 10 cm in length. Adult female amblyseius spp were left to starve for 24 hours prior to commencement of experiment. Mites were then placed on leaf discs containing Red palm mite and monitored for 24 hours. Results obtained from this experiment revealed that during the 24 hour period one female amblyseius spp consumed a total of 10 eggs, 7 nymphs' two adults whilst no males were consumed. Results of this study support the proposition that A. spp is an important mortality factor of R. indica and should be considered as a key biological control agent and should be included in an Integrated Pest Management Strategy.

Key Words: *Amblyseius spp, red palm mite, life cycle, biological control and predatory mite*

(iv) Evaluate the effect and performance of sweet cassava varieties using the three most commonly promote biostimulants in Guyana

P. Beecham and O. Homenauth

NAREI

The increase production of cassava tubers for market and industry must associate with plant nutrients and, with this purpose; the application of plant growth regulators has been studied in this crop. The objectives of this study were therefore, (i) to determine the effect of Biostimulants fertilizer on the growth and yield of two cultivars of cassava and (ii) to determine the effect of Biostimulants on tubers quality, size and weight. The experiment was conducted in an open field at Salem East Bank Essequibo and the treatments consisted of three most commonly promoted Biostimulants namely Evergreen, Bountiful harvest and Cytokin. The application rate of (10 mL/3.8L H2O) was applied by foliar spraying in three applications. The experiment was arranged in a completely randomized design, with eight treatments and

two repetitions. The tuber yield significantly increased with the different biostimulants applications, with a 30%, increase using the Evergreen when compared with the control. The total Shoot weight, Plant height and Canopy thickness showed maximum values when treated with Evergreen. The development of tubers length and diameter were significantly increased when treated with Evergreen and Bountiful harvest respectively.

Key Words: *Biostimulants, Plant growth regulators, Evergreen and Bountiful harvest and Cytokin*

(v) The use of Plant Growth Hormones (PGR'S) to enhance production of macro-propagated plantain plantlets

Aaron Hanif

NAREI

Plantain is an important staple and it is also an income earner for farmers. The production of plantain is affected by insect pests and diseases, and finding clean planting material is often a challenge for farmers. Farmers usually depend on natural regeneration of planting materials to meet their demands and these materials are often contaminated by the presence of pests and diseases. Macropropagation technology is an alternative to produce clean pest and disease free plantain seedlings since little training is needed and the cost involve is low. This study was conducted at the National Agricultural Research and Extension Institute greenhouse where plantain corms were treated with various plant growth regulators; benzylaminopurine, giberellic acid and cytokinin. There were four treatments with each treatment replicated three times. The stem fragment (PIF) technique was used and standard for each treatment. The objective was to evaluate the effectiveness of using plant growth regulators to increase macropropagated plantain plantlets. Results showed that corms treated with benzylaminopurine had an average of 16 plantlets, corms treated with gibberellic acid had an average of 5 plantlets, corms treated with cytokinin had an average of 6 plantlets and corms with no treatment had an average of 13 plantlets. Plantain corms treated with benzylaminopurine also showed earliness in the days for growth, days for growth after reactivation and days until

emergence of fifth plantlet from planting. Great potential was seen from this treatment because it can multiply more plantain seedlings using less planting material in a shorter time span.

Key Words: *Macropropagation, Plantain, Plant Growth Regulator, Benzylaminopurine, Gibberellic Acid, Cytokinin*

(vi) Comparative Study of Insect Pest and Disease of Tomato (mongol) in Open Field and Tunnel House

Therola Estwick,

NAREI

Tomato (Lycopersicon esculentum) is a major cash crop grown by farmers throughout Guyana. One of the main constraints farmers encounter in the production of tomato is pest and diseases thus causing them to rely greatly on the use of chemicals which pollute the environment and causing pests to become somewhat resistant. Consequently there is a need for alternative means of pest and disease control. The use of tunnel houses being implemented in Guyana gives a plus in understanding the effects of this system on the incidence of pest and diseases when comparing it to that of the traditional open field production. A study was carried out in NAREI to ascertain what are the major pest and diseases affecting tomato production and if the tunnel house system influences many out of these. Tomato variety Mongol was established in the two systems. Data collection commenced one week after the establishment of the crop. The abundance of insect pests on tomatoes was assessed by counting the numbers of mines, insect pests and disease on tomato leaves. Data on the abundance and yield were analysed using Analysis of Variance using general linear model procedure with significance level set at $p= 0.05$ and was subjected to a all pairwise comparison test. The total fruit weight was noted for each plant and summed up to a total for each system. Pest and disease species recorded attacking tomatoes were Ralstonia solanacearum, Pseudomonas syringae, Myzus persicae, Bemisia tabaci, Manduca quinquemaculata, Frankliniella occidentalis, Aphis gossypii, Liriomyza trifolii and a natural enemy Condylostylus sp. The tomato plants grown both in high

tunnel and open field were affected by similar species of insect pests, namely, L. trifolii, M. quinquemaculata, Frankliniella sp. The mean numbers of L. trifolii mines were significantly higher on tomatoes in tunnel house compared with those in open field also the mean number of Frankliniella sp was significantly higher in open field than tunnel house. There was a high incidence of disease only in open field (r. solanacearum and p. syringae which was the major factor for most plant mortality).The mean total fruit weights were significantly higher for tomatoes grown in the high tunnel with a total of 764 lbs (8.4lbs/plt) compared with those grown in open field with a total of 109lbs (2.4 lbs/plt). Overall the production of tomato under the high tunnel showed better results in terms of yield and the presence of disease was not seen but there was a high incidence of insect pest; One factor to be considered is the use of insect mesh to cover the sides of the tunnel house during extreme heat, so as to reduce the high incidences of pests.

***Key Words**: Tunnel House; Open field; disease; pest incidence.*

(vii) Evaluation of Organic pesticides for the control of Red Palm mite (Raoiella indica)

A. Churaman, A. Mangar, and A. Hassan,
NAREI

Red Palm Mite (Raoiella indica) is an invasive pest of coconuts and banana plants. It introduction in Guyana has led to the implementation of control strategies due to its potential economic risk to the coconut industry in Guyana. Recent investigations in several countries confirm that some plant essential oils not only repel insects, but certain specific oils and their chemical constituents have demonstrable contact and fumigant toxicity to a number of economically important insect and mite pests (Isman, 2000). As such, this field trial aimed at evaluating the efficacy of an organic insecticide-acaricide (Ararmite) (ai cinnamon oil (40%), clove oil (10%)); a multi-action adjuvant (Kompat); and a penetrant and surfactant (Bemix) on the RPM population on coconut palms in Guyana. Based on the results obtained, all three

composition of these organic products Aramite, Aramite and Bemix, and Aramite and Kompat showed no significant change in the red palm mite population.

***Key Words**: Red Palm Mite, organic insecticide, Aramite, Bemix and Kompat.*

(viii) Chemical Placement for the Control of Foliar Coconut Pests

Amrita Churaman,
NAREI

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. Ranking the third economic crop in Guyana's economy, coconut still is subjected to attack by a variety of pests including insect scales, whiteflies, red palm mites and coconut beetles. The effects of these pests on the coconut palms vary and may result in narcosis, defoliation and in severe infestations, reduction in nut size and malformation of nuts may occur (Oleke et al, 2013). Proper technique for chemical applications is vital for the success of pest control operations. This report reviewed the most effective and efficient method of chemical placement for the control of foliar coconut pests (red palm mites, whitefly, and scales). Root feeding, soil drenching and injection of the chemical (Abamectin) were reviewed. Based on observation, root feeding and injection showed potential to be used as methods of application for chemicals. Soil drenching showed no significant mode of control of the pests in comparison to the untreated control.

***Key Words**: Root feeding, soil drenching, injection, chemical control, whiteflies, red palm mites, and scales.*

(ix) Efficacy of different weed control methods in red beans (Phaseolus calcaratus L.) grown in Guyana

Leelawattie Persaud, Therola Estwick and Ariefa Hassan,
NAREI

The control of weeds is essential for the economical production of crops. Field trials were conducted at Mon Repos to determine the most effective means for controlling weeds in red beans. Three treatments were used (brush cutting, brush cutting + Metribuzin and brush cutting + Fluazifop- butyl). This experiment was carried out based on randomized complete block design with three replicates. Treatments were applied to red bean plots 20 days after germination and at 50 days after germination. In this study, results showed that brush cutting + Metribuzin and brush cutting + Fluazifop- butyl treatments were more effective in the control of both grasses and broad leaf weed populations in red beans. An integrated weed control method can be more effective in controlling weed populations.

Key Words: *weeds, production, red beans, brush cutting, Metribuzin and Fluazifop- butyl.*

(x) Control of Problematic Weeds in Maize (Zea mays L.) Grown in Guyana.

Leelawattie Persaud, Therola Estwick and Ariefa Hassan
NAREI

Weed control is an essential part of all crop production systems. Field trials were conducted at Mon Repos and Ibini to determine the most effective means for controlling weeds in maize during the critical periods of weed competition. For corn, two trials were conducted, five treatments for trial one (control, hand weeding, S- Metolachlor, S- Metolachlor + Metribuzin and 2,4 D Amine) were used and four treatments in trial two (control, Diuron, Metribuzin and hand weeding) .These studies were carried out based on randomized complete block design replicated three times. In the first trial, results showed that S- Metolachlor + Metribuzin and

2,4 D Amine reduces broad leaf weed populations and corn planted on plot treated with S-Metochlor + Metribuzin were shorter due to injuries caused by these herbicides. Grass weed populations remains dominant throughout all treatments plots as compared to broad leaf weeds populations. In the second trial hand weeding was more effective in the control of all weed types in maize, while Diuron and Metribuzin were more selective on broad leaf weeds. Other than chemical weed control means, manual weed control practices is necessary for better weed control.

Key Words: *Weed control, maize (Zea mays L.), S- Metolachlor, Diuron, Metribuzin, 2,4 D Amine and hand weeding.*

(xi) Response of Goliath sweet pepper to fertilizer regimen under open field conditions.

The Goliath sweet pepper was recently introduced in Guyana since it is a high yielder, well adapted to tropical conditions and has market acceptance. It is presently in demand by local and regional markets. Subsequently a study was initiated at NAREI on clay soil to determine the appropriate fertilizer recommendation to achieve the most favorable yields in Guyana. It has been reported that sweet pepper yield increases drastically with the application of between 512-728 kg/ha fertilizer. The experiment was organized according to a Randomized Complete Block Design with four treatments (T1: 0kg/ha, T2: 200kg/ha, T3: 400kg/ha and T4: 600kg/ha) with three replication. The Fertilizer used was 12:12:17:2 and seedlings were planted 0.45 m apart and 0.45 m between rows. Fertilizer was applied in split applications per plant at two (T1:0kg, T2: 2g, T3: 4g & T4: 8g) four (T1:0kg, T2: 2g, T3: 4g & T4: 6g) and eight (T1:0kg, T2:2g, T3:4g & T4: 6g) week intervals. There were significant differences in yield among the various treatments. The highest yield (41,245 kg/ha) was attained from treatment four while the second highest yield (26,905 kg/ha) was attained from treatment three. Treatment two obtained a yield of 11,085 kg/ha and the lowest yield (2,475 kg/ha) was achieved from treatment one (control). It is advisable to grow this variety using 600 kg fertilizer for maximum yields.

Key Words: *Goilath sweet pepper, fertilizer rates, yield, open field conditions*

(xii) Response of Goliath sweet pepper to fertilizer regimen under shaded conditions.

Goliath sweet pepper was recently introduced because of its high yielding nature, long growing, uniform bell-shaped fruits and favourable price. There are available markets for this variety both locally and internationally. It is evident that climate change is affecting agricultural production around the world. Shaded cultivation has shown to mitigate the effects of climate change by controlling temperature, moisture, nutrients and light thereby improving agricultural production. Improved growth of plants might be expected under such condition. A study was carried out at NAREI on clay soil to establish the most suitable fertilizer recommendation to accomplish maximum yield in Guyana. It has been reported that sweet pepper yield increased sharply with the application of 512-728kg/ha fertilizer. The trial was organized according in a Randomized Complete Block Design (RCBD) with four treatments (T1: 0kg/ha, T2: 200kg/ha, T3: 400kg/ha and T4: 600kg/ha) with three replication. The Fertilizer used was 12:12:17:2 and seedlings were planted 0.45m apart and 0.45m between rows. Fertilizer was applied in split applications at two (T1:0kg, T2:2g, T3:4g & T4:8g) four (T1:0kg, T2:2g, T3:4g & T4:6g) and eight (T1:0kg, T2:2g, T3:4g & T4:6g) week intervals. Significant differences were attained among the various treatments. Treatment four recorded the highest yield (50,725 kg/ha) followed by treatment three (32,935 kg/ha). Treatment two obtained a yield of 11,465 kg/ha and the lowest yield was achieved from treatment one 5,270 kg/ha. It is recommended to grow this variety under shaded cultivation and use 600kg/ha fertilizer to maximize yields.

Key Words: *Goilath sweet pepper, fertilizer rates, yield, shaded conditions*

(xiii) Response of King Arthur sweet pepper to fertilizer regimen under open field conditions.

The King Arthur sweet pepper was recently introduced to Guyana because of its high yielding nature, large uniform bell shaped fruits, good adaptability to tropical conditions and market acceptances. There is a demand for this commodity at the local and regional markets. As such a study was initiated at NAREI on clay soil to determine the appropriate fertilizer recommendation to achieve optimum yields in Guyana. It has been reported that sweet pepper yield increased radically with the application of 512-728kg/ha fertilizer. This experiment was organized according to a Randomized Complete Block Design with four treatments (T1: 0kg/ha, T2: 200kg/ha, T3: 400kg/ha and T4: 600kg/ha) with three replications. The fertilizer 12:12:17:2 was used; seedlings were planted 0.45m in rows and 0.45m between rows. Fertilizer was applied by the circular band method at two (T1:0kg, T2: 2g, T3: 4g & T4: 8g) four (T1:0kg, T2: 2g, T3: 4g & T4: 6g) and eight (T1:0kg, T2:2g, T3:4g & T4: 6g) week intervals. Significant differences were recorded among the various treatments. The highest yield (39,855kg/ha) was achieved from treatment four while the second highest yield was obtained from treatment three (27,690kg/ha). Treatment two attained the third highest yield (9,415kg/ha). The lowest yield was obtained from treatment one (3,040kg/ha). It is recommended to cultivate this variety and use 600kg/ha fertilizer to maximize yield of this variety.

Key Words: *King Arthur sweet pepper, fertilizer rates, yield, open field conditions*

(xiv) Response of King Arthur sweet pepper to fertilizer regimen under shaded conditions.

The King Arthur sweet pepper was recently introduced to Guyana because it is a high yielder, uniform bell-shaped and favourable market price. It is currently in demand by local and regional markets. It is noticeable that climate change will have tremendous negative impact on agricultural production, food supply, and food security. Shaded cultivation is known to control and regulate temperature, humidity, nutrients uptake and moisture. Improved growth of plants might be expected under such condition. A study was carried out at NAREI on clay soil to establish the most suitable fertilizer recommendation to accomplish maximum yield in Guyana. It has been reported that sweet pepper yield increased sharply with the application of 512-728kg/ha fertilizer. The trial was organized according to a Randomized Complete Block Design with four treatments (T1: 0kg/ha, T2: 200kg/ha, T3: 400kg/ha and T4: 600kg/ha) with three replication. The Fertilizer used was 12:12:17:2 and seedlings were planted 0.45m apart and 0.45m between rows. Fertilizer was applied in split applications at two (T1:0kg, T2:2g, T3:4g & T4:8g) four (T1:0kg, T2:2g, T3:4g & T4:6g) and eight (T1:0kg, T2:2g, T3:4g & T4:6g) week intervals. There were significant differences in yield among the various treatments. Treatment four recorded the highest yield (52,335 kg/ha) followed by treatment three (32,045Kg/ha) then treatment two (20,680 kg/ha). The lowest yield was achieved from treatment one (5,330Kg/ha). The yield obtained from treatment four was significantly different from all other treatment means. Treatment two was significantly different from treatment one. This variety is better grown under shaded cultivation using 600 kg/ha of fertilizer.

Key Words: *King Arthur sweet pepper, fertilizer rates, yield, shaded conditions*

(xv) Response of Marconi sweet pepper to fertilizer regimen under open field conditions.

The Marconi sweet pepper was recently introduced to Guyana because of its prolific nature, long growing season and favourable market price. It is currently in demand by the local,

regional and international markets. As such a study was initiated at NAREI on clay soil to determine the appropriate fertilizer recommendation to achieve optimum yields in Guyana. It has been reported that sweet pepper yield increased notably with the application of 512-728 kg/ha fertilizer. The experiment was organized according to a Randomized Complete Block Design with four treatments (T1: 0kg/ha, T2: 200kg/ha, T3: 400kg/ha and T4: 600kg/ha) with three replications. The Fertilizer used was 12:12:17:2 and seedlings were planted 0.5m apart and 0.5m between rows. Fertilizer was applied in split applications per plant at two (T1:0kg, T2: 4g, T3: 10g & T4: 15g) four (T1:0kg, T2: 4g, T3: 5g & T4: 10g) and eight (T1:0kg, T2:2g, T3:5g & T4: 5g) week intervals. There were significant differences in yield among the various treatments. Treatment four gave the highest yield (40,572kg/ha) followed by treatment three (26,548kg/ha) then treatment two (8,444kg/ha). This variety can be cultivated in Guyana using 600kg/ha fertilizer to increase the production of sweet pepper.

Key Words: *Marconi sweet pepper, fertilizer rates, yield, open field conditions*

(xvi) Response of Marconi sweet pepper to fertilizer regimen under shaded conditions.

The Marconi sweet pepper was recently introduced to Guyana because it is a high yielder, long growing season, favourable market price and uniform size and quality. It is presently in demand by local and international markets. It is perceptible that climate change will have considerable impact on agricultural condition, food supply, and food security. Temperature, humidity, nutrients uptake and moisture can be controlled and regulated under protected conditions, and better growth of plants may be expected. A study was conducted at NAREI on clay soil to establish the most suitable fertilizer recommendation to attain maximum yield in Guyana. It has been reported that sweet pepper yield increased sharply with the application of between 512-728kg/ha fertilizer. The trial was organized according to a Randomized complete Block Design with four treatments (T1: 0kg/ha, T2: 200kg/ha, T3: 400kg/ha and T4: 600kg/ha) with three replications. The Fertilizer used was 12:12:17:2 and seedlings were planted 0.5m apart and 0.5m between rows. Fertilizer was applied in split applications per plant at two (T1:0kg, T2: 4g, T3: 10g & T4: 15g) four (T1:0kg, T2: 4g, T3: 5g & T4: 10g)

and eight (T1:0kg, T2:2g, T3:5g & T4: 5g) week intervals. There were significant differences among the various treatments. The highest yield (48,660kg/ha) was obtained from treatment four, followed by treatment three (29,304kg/ha) then treatment two (11,868kg/ha). The lowest yield was acquired from the control (7,088kg/ha). This variety is recommended for shaded cultivation since it is high yielding and cost-effective when using 600kg/ha fertilizer.

Key Words: *Marconi sweet pepper, fertilizer rates, yield, shaded conditions.*

(xvii) Assessment of the potential water quality effects resulting from the release of vinasse, from the Bioethanol Demonstration Plant, into the surrounding waterway.

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NAREI

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

This study entails 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 downstream 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, electronic conductivity, total suspended solids, total dissolved solids, chemical oxygen demand, nitrates, orthophosphates and heavy metals including Mg, Al, Fe, Mn, Cu, Cd, Cr, Co, Ni, Pb and Zn.

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 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 plant 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. In addition, magnesium and manganese indicated an increasing trend with time and a decreasing trend with distance and may be sourced to the vinasse.

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

Key Words: *Vinasse, Water quality, Chemical Parameters, Physical Parameters*

(xviii) An evaluation of 'vinasse' (bio-ethanol effluent) and vermicompost as soil amendments for cash crop production

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NAREI

The Albion Bioethanol Demonstration Plant is designed to produce an ethanol purity level at 99.6% for fuel grade and has a 1000 litres a day capacity. Unfortunately, the waste generated from the plant represents 94% of its input and could have negative impacts on the environment. In order to be sustainable, the plant must find a way to use this waste in such a manner that will reduce environmental threats whilst simultaneously achieving sustainability.

Vermicomposting is the process where earthworms are used to break down organic matter in a controlled environment to produce a nutrient rich soil amendment.

This study was aimed at investigating the use of vinasse and vermicompost as soil amendments for cash crops. The crop selected was Brassica rappa spp. Chinesis (pakchoi) where four treatments were conducted. The experiment was conducted in the shade house at NAREI Farm (Mon Repos, Demerara, Guyana) where four treatments were done. Treatment I was the control, treatment II being vermicompost, treatment III was NPK 15:15:15 fertilizer and treatment IV as the vinasse. For each treatment, three replicates were used. In each replicate, seven plants were tested. The results regarding the number of leaves and weight of the plants were collected and statistically analyzed.

Statistical analysis revealed that the mean number of leaves for treatment I was 11.19, treatment II was 11.81, treatment III being 113.00 and treatment IV as 13.33. The statistical analysis also showed that the mean weight of plants were 269.86g , 314.25g , 372.14g and 430.02g for treatments I, II, III and IV respectively.. The LSD All Pairwise test revealed that the vinasse fertilized beds produced plants with mean number of leaves that were significantly different. In addition, the test also showed that the vinasse fertilized beds produced plants with mean weight that were significantly different from the other treatments.

The results indicate that vinasse and vermicompost can be utilized as organic replacement for inorganic fertilizers thereby producing the same quantity of produce.

Key Words: *Vinasse, Vermicompost, NPK, Soil Amendments, Shade house*

(xix) Cabbage Germination Utilising Two Media and Two Temperature Regimes

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A replicated cabbage germination study was conducted to evaluate growth media and temperature. In trial 1, 128 seeds of 'Seminis Salvation' cabbage (Date of test: 4/2015) were

counted and placed into plastic seed tray filled with commercial promix (100%) as media plus Excel ag Seed Soak 7-7-7 containing humic acid+ klep at a depth of ¼1/2 inch.

In trail 2: 1152 seeds of same variety cabbage were counted and placed into plastic tray filled with 75% promix + 25% sand as media plus seed soak applied at 5 mls per gallon of water in the soaking application only at planting in Dark Room Technology (DRT) and 200 seeds cultivated in Styrofoam box in open field cultivation using semi permeable DRT with water.

Promix played an important role in the germination of seeds in all the media. Germination with seed soak has significantly increased plant height at four days after germination with average height of 2.1 cm in DRT compared with germination using seed soak DRT with average plant height of 0.6 cm. The average height was derived from taking measurement of 10 plants each for the DRT and seed soak DRT media.

Key Words: *Cabbage, Brassica oleracea L var capitata, Salvation (Seminis), Growth and emergence, Seed Soak DRT, DRT*

(xx) A Protocol for the Planting, Managing and Cost of Establishing a Fruit Orchard in the Intermediate Savannahs of Guyana

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NAREI

A mixed fruit crop orchard containing avocado, citrus, guava, soursop and golden apple was established in the Intermediate Savannahs of Guyana, mainly to augment the production of fruit crop seeds for the national programme, and to investigate suitability of the infertile soils for orchard production. These savannahs are characterized by the low inherent fertility in both surface and subsoil. These soils are classified as well drained and Ultisols, Oxisols and Entisols predominate. The common feature of these soils is their relatively low pH, ranging from 4.3 to 5.9 within profiles and among types. The Cation Exchange Capacity and base saturation are typically low with high Al saturation. Tree crop production in these soils are oftentimes challenging because although the rainfall of 2250 mm could be described as

adequate for row crop production, 40 -60 percent of the total rain occurs from mid-April to mid-August. The protocol used in establishing the plants include animal manure as well as low grade rock phosphate in the planting pit. The growth and survivability of the plants were positive in both the wet and dry months and the percentage change in plant growth from the initial to the final height ranged from 190-500%. Floral initiation and fruiting occurred in two of the fruit types at 14 months after planting. The costs related to the establishing and maintaining of the orchard for a year was also determined.

Key words: *Intermediate Savannahs, avocado, soursop, guava, animal manure, infertile soils*

(xxi) Landrace Cassava Evaluation at Kairuni: Mass Characterization and Evaluation for Field Persistence and Yield and Yield Component Inter-Relationships among Several Local Cassava Accessions at Kairuni: 2013 and 2015.

Anchored towards the end of 2013, this field trial continued into 2014 and through 2015. The multipurpose trial comprised 35 accessions (28 bitter and 7 sweet). The 35 accessions were sown to 8 'source of accession'. The 'sources blocks' were those for Moraikobai; Mon Repos Farmer; St Cuthbert's Mission; Kairuni Cassava Gene bank; mid-Soesdyke-Linden Highway; Sweet Cassava; a block comprising four entries evaluated on site the previous season and a special home stead check; and a NAREI Mon Repos Block. Unseasonal droughts imposed too narrow replanting windows that did not allow plots to be harvested. And a weather opening June 2015 instigated the harvesting of four blocks, but a curtailed logistical window prevented replanting. Extended drought conditions did not allow further harvesting and owing to the unavailability of transportation to the Kairuni site the status of the plot as at the end of 2015 could not be accounted for.

Key Words: *Manihot esculentus, Landrace cassava varieties, field persistence, yield components, morphological characterization.*

(xxii) Management of Black Sigatoka Disease (BSD) using an Integrated Management Approach

Sridevi Nanku and Aaron Haniff

Black Sigatoka Disease (BSD) caused by Mycosphaerella fijiensis is a major constraint to plantain production in Guyana. It was first reported in 2008 and later confirmed by CABI in 2010. This disease affected the crop green life and yield and this effect was noted in 2012 when plantain export was decreased to 100%. The objective of this study is to develop IPM tools that can be used for controlling BSD by evaluating the different sanitation practices used along with plant nutrition, weed control, drainage and irrigation, monitoring of pests and other diseases, monitoring of the disease severity and fungicides application. A test trial was conducted using Randomized Complete Block Design (RCBD) with three replicates. The treatments used were different sanitation practices. Results from the field trial showed that the average number of leaves per plant were 6-10 with an average of four leaves at harvest.

Key Words: *Black Sigatoka Disease (BSD), Sanitation Practices, Infection Index, Yield, Production*

2.0 STATUS REPORTS OF WORK IN PROGRESS/INITATED

(i) Determination of the suitability of *Pennisetum Purpureum (*Giant King Grass) for the production of pellets for coal replacement

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NAREI

The Giant King Grass was planted in the compound of the National Agriculture Research and Extension Institute on September 26, 2014. One stalk of the grass was sourced and cut into three pieces and left for two days, after which shoots began to develop. The three stalks were transplanted in the field at a distance of 0.5m apart. The grass was watered daily and continuously monitored. Observations revealed that the king grass was well suited for the field conditions. After six months on, March 11 2014, it was harvested and various parameters were evaluated. After harvesting, the surface area of the roots and shoots for each plant was determined with the use of the tape measure. Moreover, the stalks from each mound were placed separately to dry and upon drying, the stalks were tied with a rope and the average weight was determined using a hand scale. With the use of a tape measure, the average heights of the stalks were recorded for each mound. Additionally, the shoots and stalks that were cut, were counted and noted.

Upon the first harvesting of the grass, it was once more left to grow. The grass was watered and monitored and after six months, the second harvesting was done. On Sept 09, 2015 the grass was cut and similar data as the first harvesting, was collected. The Table 1 below displays the data for both the first and second harvesting of the Giant King Grass.

Table 1: Showing the results of Giant King Grass harvested after six months

Stalks	# of Shoots/Stalks		Average Weight (kg)		Average Height (m)		Surface cover (m)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
1	100	156	60	65	3.6	4.2	0.6	0.86
2	66	112	50	82	3.7	4.3	0.45	0.76
3	85	126	60	63	3.7	4.4	0.6	0.70

(ii) Nutrient studies on Sour-sop Cultivation and production.

Initially four soursop growing locations (Coverden-EBD, Bendorf EBE, NAREI Kairuni, and NAREI Mon Repos) were targeted for observation and soil fertility monitoring. A brochure on soursop cultivation in Guyana was produced based on information gathered from questionnaires. An additional location (NAREI Ebini) was selected in 2015. Soils' pH at all locations were below optimum range (5.5-6.5), applications of limestone were made. Two locations ( ) are within the optimum pH range. Liming to optimize pH continues at other locations. In 2016, emphasis will be placed on maintaining pH within range and monitoring macro and micro nutrient levels for optimal plant uptake and production. Small plots will be established in the Intermediate Savannahs to test the suitability of the area for cultivation.

(iii) Nutrient Studies in Cherry Cultivation.

Work continued in 2015 on two large scale cherry producers at Coverden EBD and Maripa EBE to balance macronutrients in cherry fields and correlate soils' micro-nutrient status with cherry production and productivity. Soil sampling and lime stone application was done at Coverden. Work was done on three additional locations: NAREI Mon Repos and Kairuni and Bendorf. For all three locations soil sampling and limestone application were done based on recommendations. The application of organic matter was recommended for Bendorf. Harvesting was done from Plot at Mon Repos: 100 fruit weight (345.3g), avg. diameter (1.4cm).

(iv) Soil Micro-Biology: Inoculant production

6 kg of inoculant was produced from two strains of rhizobium bacteria extracted from Jack bean and Sunn hemp plants that were acquired from GuySuCo. These strains along with two strains extracted from the sesbania plant spp are currently being evaluated on Minica IV and feijou to test their effectiveness for nitrogen fixation against commercial strain (Tal 178). The efficacy of nodules from the sunn hemp and Sesbania white stem strains are performing comparably to Tal 178. Harvesting and data collection in progress.

46Kg of Inoculant produced for the year: 34 kg was requested by GuySuCo.

(v) The use of Mycorrhiza in substrate preparation for seedling production

The use of commercial mycorrhiza on the growth and yield of Bullnose sweet pepper is currently being evaluated at Mon Repos. Visual observations at seedling stage showed that the 100% Vermicompost + Mycorrhiza is best compared to coconut coir, paddy husk and rice husk biochar. Data collection is in progress. The preparation of 5 kg Mycorrhiza inoculant is projected for 2016.

(vi) Production of Fruit and Leafy Type Vegetables under Hydroponics Conditions

Several modifications were made to the facility to make it favorable for plant growth: (a) the reduction of excessive temperature in the facility from 40 0C to 25 0C was achieved by the addition of two vents at the northern and southern ends; (b) the flow rate of the system was reduced from 7 liters/min to 4 litres/min to allow for longer retention of nutrient solution in the system; (c) the reduction of high electrical conductivity of nutrient solution from 2 mmhos/cm to 0.6 mmhos/cm and (d) increase holding capacity of leafy type plants from 200 to 392 by increasing the length of the pipe. As a result of these interventions one cropping cycle of tomatoes is successfully being grown (fruiting stage) in the facility.

(vii) Production of Intercropped Vegetables under Shade house Conditions

Costs of production (COP) were established for cucumber- $1,067,000/acre; lettuce - $997,350 and pak choy - $997,350 grown in the kitchen garden. One cropping cycle of yellow split peas was successfully grown under shaded conditions (need data on initial agronomic parameters). COP was established for crops grown in the shade house Field 17: Cabbage (organic) $ 366,617/acre; cauliflower (organic) $369,117/acre; cucumber $892,597/acre and tomato $750,987/acre. There was zero use of pesticides due to the use of insect repellant plants (oregano and marigold) and insect traps as an IPM tool to minimize the use of chemicals in the shade house. Flat beds in the eastern section of the shade house will be converted to raised beds to prevent flooding.

(viii) The Use of Grass Mulch to Develop a Plough Layer on Clay Raised Beds in Field 17

Stacked fresh and dry grass (40 cm high) was used to improve soil quality of a plot in Field 17 of NAREI. After 18 months: bulk density decreased for T1 (control), T2 (dry grass) and T3 (fresh grass) from 1.03g/cm3, 0.99g/cm3 and 0.93g/cm3 to 0.92g/cm3, 0.87g/cm3 and 0.97g/cm3 respectively and soil colour changed from a light to a darker brown based on Munsell colour chart.

(ix) The use of Sunn hemp in management of nematodes under shaded vegetable cultivation.

All crops grown in the shade house in Field 17 are severely affected by nematodes since sandy soils are prone to nematodes. Soil sterilization using heat has been partially successful with controlling this pest since it is not easily controlled. Another approach utilized was soil sterilization accompanied by chemical application. This approach is successful only for a short period of time, thus the need to find another method for nematode control. The use of Sunn hemp has been reported to suppress weeds, slows soil erosion, and reduces root-knot nematode

populations. Data generated from research at NAREI showed that the incorporation of Sunn hemp at 1.45kg/m² was 100 % effective in controlling nematodes in test crops after three applications. Further research will continued in 2016 to evaluate the long terms effects of sunn hemp on nematode control.

(x) Investigating the Effectiveness of Locally Available Liming Materials on Local Soils.

The inherent acidic nature of local soils dictates that liming is necessary to achieve optimum plant growth and yield. Thus, there is need to test these various liming materials for their various interactions with different soil types and more importantly the rate and timing of applications to achieve the desired pH. Laboratory observations were conducted on two soil types Onverwagt clay (Unit 41) and Tabela Sand (Unit 800) using four liming materials: limestone, low grade rock phosphate, agrical (an organic calcium product) and a by-product of GWI water clarification process (GWI Effluent). Analyses indicated that Calcium Carbonate, Low Grade Rock Phosphate and GWI Effluent were effective in raising the pH within optimum range. Agrical had little effect on exchangeable acidity and pH but increased electrical conductivity on Onverwagt clay. Analyses on Tabela sand are in progress.

(xi) The Natural Enemies associated with Raoiella Indica Hirst

Raoiella Indica Hirst has been classified as a quarantine pest since its introduction in Guyana. The damages inflicted by this phytophagous mite on coconut palms, being a source of nutrition and income for small farmers has derived the need for the implementation of an Integrated Pest Management Strategy with the inclusion of predaceous mites found in association with R. Indica populations.

Thus far based on samples received by the department of Plant Pathology Entomology and Weed Science from the different natural regions affected by red palm mite a number of Natural

enemies have been found associated with R. Indica Populations. These natural enemies include: Amblyseius spp, Chrysoperla spp, Bdella spp, coleoptera spp and Aleurodothrips fasciapennis (Franklin).

Amblyseius spp was the most predominant natural enemy found in association with R. Indica Hirst populations and therefore arenas were established to facilitate the rearing and multiplication of predatory mite Amblyseius spp for further release in identified quarantine areas with aim of reducing red palm mite densities.

(xii) Response of carrot (Daucus carota L.) variety (New Kuruda) to shade and semi shaded conditions.

Increase in production of carrot in Guyana is a crucial step towards the reduction in the import of the commodity. Nutritional value of the vegetables has placed it in high demand, hence the drastic increase in importation. There are no reports available locally on the fertiliser requirements for the growth and development on the commodity. The experiment was carried out under a tunnel house condition. The recommended fertiliser rates used were N -150kg/ha, P2O5 - 110kg/ha, K2O - 110kg/ha (applied at sowing, two and four weeks after germination respectively) seedlings were thinned out at two weeks at a spacing of 10cm apart and 20cm between rows. Carrots were harvested 77 days after planting. Data collected showed that 70% of the carrot harvested was marketable. A total of 52.7 kg of carrots was harvested from 502 plants. The area consisted of 28 m2. In each m2 an average of 18 carrots was harvested with an average weight of 0.104 kg per root. Each m2 produced an average weight of 1.8kg. From the 52.7kg harvested 6.8kg was damaged (cracked), 3.09 kg deformed; 29.09kg was marketable, while the remaining was too underdeveloped, deformed, damaged and unmarketable.

The production of carrots on a large scale will be more economically feasible, than planting on a small scale, once all requirements are met. The only limitation to the production of the commodity will be labour. The loss that may occur because of cracks and deformity, these

unmarketable materials can be canned or shredded and sold locally. They are limitless potential for the commodity locally.

(xiii) Introduction/Reintroduction of Amjad Sweet potato in farming communities.

This project was established in Parika Backdam and at Kuru Kuru during 2015. Amjad sweet potato slips were distributed to five farmers in Parika Backdam and one farmer in Kuru Kuru. Amjad sweet potato plants in black potting bags were distributed to one farmer at Kuru Kuru. Two farmers in Parika Backdam successfully cultivated, multiplied and distributed the Amjad sweet potato variety to other farmers in the area. One farmer in Parika harvested 160 lbs. of Amjad sweet potato from 60 plants which is equivalent to 8,010 lbs. per acre, while twenty three pounds were harvested from 10 plants which is equivalent to 6,900 lbs. per acre. Ninety percent (90%) of the tubers harvested were marketable. Amjad sweet potato tubers were introduced to the market in Parika and were high in demand. Approximately fifteen farmers have collected Amjad sweet potato slips for cultivation in Parika and Ruby Backdam. Amjad sweet potato was successfully cultivated on two farmers plot at Kuru Kuru, however, the yields obtained were very low which was highly due to the dry weather and lack of irrigation.

(xiv) Beauregard Sweet Potato

During the month of October, 2015, approximately 6383 Beauregard sweet potato slips were sourced from Jamaica and planted in field 17. The slips were planted on ridges approximately 30 cm apart. The plot was irrigated utilizing the sprinkler system. General agricultural practices were maintained for weed control (Manually and Chemically-Fusil), Fertilizer application (15:15:15) at the rate of 150 kg/ha and insect control- Pheromone for the control of Cylas Formicarius and Fastac for the control of Mealy bug. Prolong of dry weather has impacted negatively on the establishment and survival of the plants. To date, there is approximately fifty five percent (55%) plant establishment and survival. There is also an exceptionally high level of infestation of the sweet potato weevil, Cylas formicarius, as

hundreds of the weevils are captured by the pheromone traps. Chemical control (VYD8) is being applied also for increased control of the pest.

(xv) **Butternut Squash Production**

Butternut squash (Cucurbita morschata) has a sweet, nutty taste similar to that of a pumpkin. It has yellow skin and orange fleshy pulp. When ripe, it turns increasingly deep orange, and becomes sweeter and richer. It grows on a vine.

Squash takes a lot of space in gardens. One squash plant on the ground can exceed 15 feet across. Growing butternut squash on trellis can help eliminate the problem of space.
Butternut squash was one of the crops identified under the National Agriculture Strategy 2013-2020 because of its nutritional and health benefits.

This investigation was conducted to evaluate yield of butternut squash on trellis. This trial was conducted at NAREI Field Station Mon Repos. Seeds (variety: Waltham Butternut) were planted in mounds with a spacing of 2.5m between rows and 0.6m between plants. The plot size was 123.2m X 1.52m. Fertilizers (6g of12:12:17:2) were applied at 3 and 6 weeks after planting. The average # of fruits per vine obtained was 7 fruits and the average weight of fruit was 0.7-0.9 kg. A total of 139kg of butternut squash was harvested. The main contributing factor for this yield was due to poor germination of seeds.

(xvi) Soursop Production

Soursop has many health benefits. The seeds, which have emetic properties, can be used in the treatment of vomiting. The juice of the fruit can be taken orally as a remedy for urethritis, haematuria and liver ailments.

In Guyana, it is projected that the export target volume of more than 20 tonnes of soursop should be achieved in 2020. The demand for soursop to be consumed freshly and processed as

juice has been on the increase in Guyana. This is because of its great health benefits, the major one being its anti cancer properties. Therefore there is a need to increase production to satisfy this demand.

The main objective of this project is to develop a technical pack for soursop to improve its production and productivity.

This trial is being conducted at NAREI compound Mon Repos. Plants were spaced 5 x 5m apart. Planting holes were made with the dimensions 0.6x 0.6 x 0.45m and filled with top soil and 250g of NPK 15:15:15. Fertilizer was applied when plants were three months. To date plants are five months old.

(xvii) Saijan Production

Saijan, Moringa oleifera known as the "Miracle Tree" and the "Elixir of Long Life" is a drought-resistant tree, native to the southern foothills of the Himalayas in northwestern India, and is widely cultivated in tropical and subtropical areas for human consumption.

Moringa oleifera has many health benefits. The leaves are rich in amino acids, vitamins and minerals. It is used for skin disorder treatment, diabetes, sleep improvement, relief for anxiety and depression.

It is identified as one of the crop for potential exportation under the National Agriculture Strategy 2013-2020.

This trial is being conducted at NAREI Mon Repos and Kairuni Nursery the Soesdyke Linden Highway. Plants were spaced 2.5m apart. Planting were made with the dimensions 0.4x 0.4m. To date plants are eleven months and a total of 2kg of seeds were harvested.

(xviii) Micropropagation protocol for Pineapple and Sweet Potato

A micropropagation protocol for two crops (Pineapple and Sweet potato) is in the process of being completed. Optimistic results have been gained in other crops (Cassava, Plantain & Bananas and Coconut). The almost completed protocols are in a refining state and need to be tested in other varieties to ensure the effectiveness in a wide range of accessions (e.g. the pineapple protocol was completed only with Sugar loaf pine, but is unknown it effectiveness in Smooth cayenne or Tiger head pineapples). Some of the results on the use of the protocols.

1. In pineapple, the multiplication rate achieved was in the proportion of 1:5 – 1:7 after the second subculture. In the hardening process 450 plantlets were transfer to pot with 72.8% survival (328 plantlets).
2. In sweet potatoes the multiplication rate was the 1:4 after the second subculture. In the hardening process an 88% survival was attain 250 plantlets were transfer to pots 220 survive.
3. In other crops like cassava and plantains and banana multiplication rates of 1:3 and 1:5 respectively was obtained.
4. Advances have been accomplished with the in vitro culturing of zygotic embryos excise from dry coconuts. A high level of germination (90%) was observe on all the accession. However, not all the embryos germinate uniformly and lack of plant development was observing in a great number of them. Better responses were observed in the hardening of coconut plantlets reaching 88.8% survival.

With the idea of protecting our native plant genetic germplasm and having it readily available for use in a given time, the in vitro conservation techniques offer a secure tool in achieving this goal. In this regard, a local germplasm collection of some of the most important crop was initiated in 2015. Collecting 12 different accession of cassava, 8 accession for plantain and bananas, 5 accessions for Sweet potato, 3 accession for pineapple and 8 accessions of coconut palms not clearly identify (18-months, 3 years, 5 years and dwarf nuts green and yellow).

In house training of five (5) from the 8 staff members of the department was done during 2015. The training activities included theoretical and practical sessions, introducing them to the Biotechnology-Tissue culture techniques. Results of these training activities can be seen in the multiplication protocols for pineapple and sweet potato.

(xix) Landrace Cassava Evaluation at Kairuni: Comparative Yield Performance Evaluation of 5 Putative Drought-tolerant Cassava Accessions Along Side Two Drought-tolerant and One Drought-intolerant Check Varieties: 2015.

This trial was anchored in February 2015 in a split-plot design in triplicates. The putative drought-tolerant landrace accessions (ABS 34, MDBS 21, PBL 5, and GT 2) were advanced from the previous 2013-2015 'Mass Characterization and Evaluation for Field Persistence' field study. The drought-tolerant controls were control White stem and Brown stem, and the intolerant check was Pomeroon stick. Plots were scored for shoot emergence and growth vigour at 2 and 4 weeks respectively. Plot patching was done in the 4th week. An extended wait for the procurement of manure extended into a period when transportation could not be made available. Towards the end of June plots were overgrown with weeds to the extent that the trial had to be abandoned.

(xx) Compilation of '777 Responses to Queries on Crop Science Relative to Guyana'.

As an in-house desk assignment this compilation sought to update the status of crop science research for non-traditional crops relevant to Guyana. The compilation highlights innovative ideas and state-of-the-art information for using a research approach to move non-traditional crop agriculture onto a sustainable commercial pedestal and open-row field cropping specifically, on an industrial trajectory. The background to this concern is prompted by a multitude of questions and rooted in several cross-cutting issues.

Drawn mainly from more than 3 decades in academia, collaboration with fellow researchers and interacting with farmers and agro-produce distributors, compilation of this general module samples 14 crop-related thematic research specializations: Agricultural policy, Agro-commodity marketing, biosafety, biotechnology, climate change, crop ecology, crop improvement, crop networking, general crop production, food security, open-row field

cropping, organic farming, plant genetic resources, and seed security and the seed industry. The results are responses to more than 750 queries to inform on the status of crop science research applicable to Guyana. The intent is not only to concisely document a body of information, but also to provide fellow plant science researchers and policymakers in the country a basis upon which they can use some options to better help improve agricultural research for the betterment of our deserving farmers, especially in the non-traditional crop agriculture sector.

An in-house reviewed draft has since seen a second tier circulation outside the institute.

(xxi) Release of a 2015 Reprinted Publication of 'An Analysis of the State of Plant Genetic Resources for Food and Agriculture in Guyana-Security in Diversity-2012'.

In its second reprint, the original 2012 80-page document has been expanded to a 149-page picture-illustrated documentation. It was distilled from outputs of a Joint NAREI-FAO Project for the establishment of a National Information Sharing Mechanism (NISM) on the implementation of the Global Plan of Action (GPA) for the conservation and sustainable utilization of Plant Genetic Resources for Food and Agriculture (PGRFA), and the preparation of a country report of an assessment of the state of PGRFA in the country.

(xxii) Status of the Implementation of the National Bosafety Frameworks for Guyana and some concerns and implications

The Guyana project is a national component of the UNEP/GEF Regional Project for Implementing National Biosafety Frameworks in the Caribbean Sub-region. It is expected to facilitate the development of National Biosafety Frameworks (NBF) compliant with the Cartagena Protocol on Biosafety (CPB) in Guyana and 11 other Caribbean countries. The initial duration for the Regional Project was thirty-seven (37) months to be completed as of June 30-2015. Guyana signed on to the Partnership Agreement. The initial duration of the project extended was to December 31, 2015. In an effort to address issues concerning

achievements of stated deliverables from the majority of countries, the Regional Project is currently seeking a second Project extension through UNEP/GEF from January to June 2016.

The Regional Project comprised 5 components:

1. Component 1 **Nationally**: *Establishment of National Legal Frameworks for Biosafety, Biotechnology and Biosecurity*.
2. Component 2 **Nationally and Regionally**: *Institutional Capacity Building*
3. Component 3 **Nationally and Regionally**: *Human Resource Development*
4. Component 4 **Nationally and Regionally**: *Strengthening Biosafety Information*
5. Component 5 **Regionally**: *Regional Processes to Support Sustainability*

The National Executing Agency is the EPA (Guyana). A National Steering Committee (NSC) comprising representatives of key stakeholder agencies is facilitating project implementation. The active stakeholder agencies are the EPA (Guyana), UG Faculties of Natural Sciences and Agriculture and Forestry, Government Analyst Food and Drugs Department, the National Bureau of Standards, the Guyana Revenue Authority, GUYSUCO, and the Ministry of Natural Resources and the Environment.

(xxiii) Specific Project Deliverables: Documentations

Development of the final draft Biosafety, Biotechnology and Biosecurity Bill and Regulations; Development of a National Institutional Framework as the Administrative structure for the management of Biotechnology/Biosafety initiatives.

The current draft documents are currently up for the attention of the EPA (Guyana) Board. Following, they would submitted to the Office of the Minister of Natural Resources and the Environment. It is expected that at this Ministerial level the Official draft would be filter back to the concerned agencies.

(xxiv) Evaluation of four plant spacing on the yield of two corn varieties.

The study was a randomized complete block design trial with three replications, four treatments and 2 varieties. The individual plot sizes were 1000 x 500 cm, with a 1m wide passage way between each replication. The corn seeds were planted in four rows per plot and 52 seeds were planted per plot. The plant to plant distance within each row was 60cm and between rows were 40, 75, 90, and 100 cm. The sowing of the seeds was done by hand at a depth of 5-7 cm, one seed per hole and the seeds were then covered with soil. A template/stencil was made of wood for the planting holes. The template ensured that the seeds were planted at the required distance. Plants were resupplied at day 4 to ensure that each plot had 52 plants.

The fertilizer regime used included the following:

1. 15:15:15 at the planting rate of 50kg/ha
2. 35kg of nitrogen in the form of urea was applied in 2 equal amounts.
3. First application of urea was applied 25-30 days after planting.
4. Second application of urea was applied at 60 days after planting.

Weed Control:

Glysofate was used at the pre-emergent stage of planting while gramoxzone was used at the post-emergent stage. All safety protocols were followed when those weedicides were administered.

Irrigation:

1. In addition to rainfall, irrigation water was supplied when it was required.
2. Harvesting:
3. Harvesting was done manually.

Table 2 showed the production parameters of the corn spacing trials on the two corn varieties.

Table 2: Production Parameters of Corn Spacing Trials, 2015

Parameters	Results				
Date of sowing	03-12-2014				
Date of germination	06-12-2014				
Days required for germination	3				
Total seed used	104 per plot x 26				
Fertilizer application	As stated above				
Plot size	10m x 5.5m				
Number of plants per plot	52				
Number of plants per m square	40 cm	60 cm	75 cm	100 cm	
	6	4	4	4	
Days to Maturity	109				
Plant height (cm) Reps 2 & 3 were grazed by cattle Jan 2015	Pioneer (cm)				
	Rep 1		Rep 2		Rep 3
	167.7		130.15		103.5
	CARDI C-001 (cm)				
	149.75		118.375		98.4
Ave. number of ears per plant Reps 2 & 3 were grazed by cattle Jan 2015	Pioneer				
	Rep 1		Rep 2		Rep 3
	1.39		1.36		1.045
	CARDI C-001				
	1.652		1.457		1.135
Ear height (cm) Reps 2 & 3 were grazed by cattle	Pioneer (cm)				
	Rep 1		Rep 2		Rep 3

Jan 2015	64.4	48.5	33.75
	CARDI C 001 (cm)		
	64.65	51.55	44.6
Rainfall to the end of the Trial	605.3		

Table 3 showed the response to planting space for the Pioneer variety.

Table 3: Variety Response to Plant Spacing, 2015

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)	Average number of ears/ plant	Kg/ha
40	300	195	14	23	60.5	1.11	12,974
75	483	253	12	27	57	1.20	8,864
90	500	345	12	35.5	69.5	1.41	16,698
100	423	193	14	26	53	1.39	10,726
Variety CARDI C-001							
40	466	270	12	26.5	72	1.24	17,034
75	522	340	12	39	74.5	1.54	21,477
90	588	256	14	36.5	71	1.48	21,478
100	470	260	14	32	75	1.39	18,681

Unfortunately this study could not have been analyzed as a result of mistakes that were made during the study. However, the raw data, as presented above, did provide encouraging trends that show that the Variety CARDI C-001 responded better at 75 cm and 90 cm spacing between rows. Consequently, this CARDI C-001 variety would be cultivated on a larger scale during 2016 using both 75 cm and 90 cm spacing between rows and 60 cm within rows and the results will be furthered analyzed taking NAREI one step closer to the development of a technological package for corn production within the Immediate Savannahs.

The Pioneer seed from the experiment was later cleaned using the Multi-purpose seed cleaner and a total of 680kg of seed was recovered of which 272kg was transferred to Mon Repos for storage and distribution while 100 kg was sold as stock feed and the remainder was distributed to farming communities between Kimbia and Calcuni in the Berbice River.

The harvested CARDI C-001 seed (700kg) was cleaned and given to farming communities within the Berbice River as seed material.

Both trials (spacing and fertilizer) were repeated during the second planting season of 2015 however they were both aborted when it was detected that the Pioneer variety was of the hybrid strain coupled with an extremely poor plant population.

Table 4 showed the Rainfall during the growing period

Table 4: Rainfall data during the Dec-March period 2014 and 2015

Months	Rainfall (mm) 2014	Rainfall (mm) 2015	Rainfall days 2014	Rainfall days 2015
Dec.	140.7	129.3	16	20
Jan	123.6	263.3	21	18
Feb	181.2	102.3	22	21
March	4.1	99.0	05	22
Total available during the period	449.6	593.9	64	67

Table # 4 shows that even though the rainfall days differ by 3 days during Dec-March 2014 and 2015 the precipitation was 24.3% higher during 2015 than during 2014.

(xxv) Spices Project

Four spices viz. black pepper, turmeric, ginger and nutmeg was targeted under the spices program in 2015.

(a) Turmeric (Curcuma longa) and Ginger (Zingiber officinale)

Twenty eight farmers from Region # 1 received in excess of **22,000lbs** of turmeric planting materials from NAREI free of cost. These Planting materials/ rhizomes were used to further expand turmeric cultivation in Region # 1. The increase production from expanded turmeric cultivation will supply the turmeric factory soon to be opened at Hosororo with fresh turmeric rhizomes.

Fertilizers trials were done on ginger and turmeric at NAREI using Urea, MOP and TSP. These fertilizers were applied as a basal dose, 40 DAP and 90 DAP. Both ginger and turmeric exhibited excellent vegetative growth and showed no signs of pest and diseases infestation. At the time of

harvesting ginger rhizomes showed signs of hollowness. Ginger rhizomes were small and slender compared to the bold type that was used as planting materials.

Harvested turmeric rhizomes were also very small in size compared to accession # 14 that was used as planting materials.Ginger and turmeric rhizomes were affected by the high temperature and long dry spell experienced throughout Guyana.

(b) Nutmeg (Myristica fragrans)

- 64 nutmeg seeds sown in the nursery at NAREI are yet to be germinated
- There are 19 nutmeg seedlings growing vigorously in the nursery at NAREI which will soon be grafted.

Turmeric and ginger germplasms are maintained in the NAREI nursery. These materials when harvested will be used as planting materials to continue in the preservation and conservation of these germplasms.

© Black Pepper (Piper nigrum)

The multiplication of black pepper cuttings continues at NAREI in the nursery. These cuttings will be used to expand black pepper cultivation in Guyana and also distributed to interested farmers. There are **1,200** black pepper cuttings presently available in the nursery at NAREI. Black pepper harvested in field at NAREI was sun dried and used at exhibitions. Small packets of pepper corns were distributed to the general public at all exhibitions during agriculture month.

(c) Nutmeg (*Myristica fragrans*)

- 64 nutmeg seeds sown in the nursery at NAREI are yet to be germinated
- There are 19 nutmeg seedlings growing vigorously in the nursery at NAREI which will soon be grafted.

(xxvi) Culinary Herbs

Culinary herbs, nor container farming are new concepts in Guyana, but modern planting techniques, newer herbal varieties and proper food storage are ever evolving areas hence the need for the transference of said knowledge and technology.

Herbs have delicate structures and mostly willowy in nature hence shaded conditions aid in their unhampered growth and development, whilst growing in containers promotes using these condiments while fresh, since with containers they occupy less space, placing them on balconies, window sills and even in one's kitchen is seen as a benefit. They are also easily pruned in containers whilst they add even another benefit of being natures natural repellant. Consequently, a study was initiated in NAREI with various soil amendments to determine what seeds germinated the best on what substrate and there general growth pattern thereafter. Herbs selected for this study included: Sage, Dill, Fennel, Sweet marjoram, a newer variety of fine thyme, variegated broad leaf thyme, basil (purple leaf, lemon leaf and Italian broad leaf), Coriander, Culantro, Bay leaf and Parsley. Seeds germinated faster in the promix and vermicompost than in the nursery substrate and for general growth it was noticed that the plants did well in the vermicompost substrate with liberal application of pen manure being added to help with the soil structure (maintain compaction of the soil around the roots of the plants) but aiding easy drainage of water in the bins. Some seedlings germinated early by one day, but the rest of data collected within the two to three weeks germination period proved that between the promix and vermicompost seedlings germinated or reached a two leaf stage with 90% occupancy in trays, whereas in the nursery mixture there was a 50% rate of germination even after thinning out and replacements, which would suggest lack of seedling nutrients. General plant growth, in the various bins there was noticeable differences in plant vegetation. Vermicompost along with liberal pen manure showed differences in plant foliage. More leaves and flowers were present, plants height was increased by 1-2cm in height. An overall growth increase of 20% was recorded in the bin containing vermicompost and pen manure compared to that of the nursery mixture with minimal pen manure.

(xxvii) Coconut Project in Wakenaam and Pomeroon

NAREI has undertaken to treat coconut trees on Wakenaam Island for red palm mite (RPM) insect using abamectin. The treatment of coconut trees commenced on the July 2014 for the period from July 2014 to December 2014, a number of 21,640 coconut trees were treated.

The period from January 2015 to December 2015, a number of 25,393 trees were treated by injection method and 1,462 small trees were sprayed using a mist blower.

The majority of trees treated in 2015 were done by NAREI technical personnel's. Initially 6 hired workers were paid to drill holes and administer 10ml of inisan in each tree. This exercise was done on a weekly basis, working for three days per week. At the end of the exercise for 2015 most of the trees treated were done by farmers with inisan provided by NAREI. Small coconut trees were sprayed with abamectin.

To date coconut palm trees are continuously being treated for RPM. The insecticide /arachnicide is currently being applied by farmers. NAREI is continuously providing the chemical Inisan to farmers who have mature palms; however this is done with careful monitoring by NAREI technical personnel so as to ensure the chemical is used for its intended purpose. Trees that are treated are given a period of 5 weeks before any harvesting can be done (7 days more than what is recommended on the label of the chemical).

The chemicals distributed to farmers are recorded in a "Chemicals Record Book' where the farmers name, address, farm address, trees treated, acreage, amount of chemical given, contact number and signature is recorded.

RPM control program in Pomeroon (Distribution of chemicals and monitoring of treatment of coconut trees) lower Pomeroon River (Martindale, Marlbrough, Cozier canal, Lyldale, Friendship, Strong hope canal).

Total number of farmers visited: 165

Total number of acres:	3223 ac
Total number (bottle) of chemical distributed:	562 Inimectin (250 ml)
	657isan (1000 ml)

This activity started in 2015-10-05. To date Inisan is being distributed to each farmer in a systematic manner.

3.0 EXTENSION, TRAINING AND PROVISION OF SERVICES

Farm Visits

A total of 45526 farm visits were conducted in 2014 across the country. Regions 5 and 3 continue to be the better achievers in both farm visits and farmers contact. The density of cash crop farms and the level of organization of farmers groups are factors influencing these regions. 45526 farm visits is indeed a far cry from the full potential of the staff establishment but accessibility, finance and hostility during the election period did play a negative influence on achieving the full potential. The breakdown of farm visits by Regions is shown in table 5. below.

Table 5: Farm Visit and Farmers Contact, 2015

Activity/ Region	1	2	3	4	5	6	7	8	9	10	Total
Farm and Field Visits	3126	5622	6912	7728	8211	6291	2820	1192	2826	798	45526
# daily log submitted	3021	5492	6687	7721	7793	6001	2520	925	2284	922	43366
Clinics - # farmers	0	44	216	22	48	24	0	0	0	26	380
Farmers Meeting.	4	61	42	33	45	21	2	6	4	12	230
Attendance	112	1403	671	686	1260	336	45	87	43	132	4775

Farmers Clinic

While farmers diagnostic clinics were not operational to their fullest, they were temporarily implemented in some areas in times of difficulties (during the flood periods) and recorded 3420 with the highest numbers recorded in Black Bush Polder, East Coast Demerara and West Bank Demerara.

Farmers Meeting

A 27 % increase in farmers meetings from 2014 was recorded and was used as a strategy to improve farmers contact during difficult times.

Farmers Registration

As displayed below Table 6 showed the total number of Farmers Registration, Acreage under Cultivation and Average Holdings. Total farmers registered is 17222 with region 2 recording the highest number while region 10 the lowest (this is due to lost records when the office caught fire). However, region 3 recorded the highest cultivated acreage. Average holding is largest in region three and may well be influenced by the high acreages under pineapples, orchards and coconuts in comparison to region 5. Collection of data will continue in 2016.

Table 6: Farmers Registration, Acreage under Cultivation and Average Holdings, 2015

Region	1	2	3	4	5	6	7	8	9	10	Total
Farmers registered	427	4302	2825	3601	2132	2011	681	629	432	182	17222
Acres under cultivation	802.59	10612.23	10827.22	9122.7	3324.46	4802.7	408.62	1780.31	647.31	241.82	42596.61
ave holding	1.88	2.47	3.83	2.53	1.56	2.39	0.60	2.83	1.50	1.33	2.47

Farmers Field School/ Demonstration plots

A total of 18 plantain management demonstration plots used for training purposes during the year. Twenty two sessions of farmer's field school were conducted with a total of 423 farmers trained in the management of plantains. Seven plots were harvested for the first time, Six for the 2nd time and nine harvested for the 3 rd time. Four plots were ploughed in while a further four were established.

One hundred and fifty other demo plots were also established or maintained during the period. These are as follows:-

i) Sweet potato lures – 79 demo plots were established and 872 farmers visits took place. The technology transfer can be considered successful. The main problem is now availability of lures.

ii) Amjad Sweet Potato – 37 plots of Amjad sweet potatoes were established in region 3 and six respectively. A total of 183 farmers are now actively

involved in establishing small plots. The potato, from feedback, is taking the market and sought after for the local sweet potato chip industry.

iii) Diamond back moth male attractant lures – 34 plots were established in collaboration with Caribbean chemicals and monitored in regions 3,4 and 6. Farmers' acceptance of this strategy is very poor since it does not produce immediate result. When farmers would have invested large sums of money in their cabbage crop they will not take any chance with a slow method of control.

Agronomy

(i) Protected Agriculture.

Protected systems seem to have hit stagnation in 2015. Only five new structures were established while a large number have become nonfunctional. Low prices in the first half of the year had literally pushed many shade house farmers out of business. Only the experience farmers continue to cultivate. The use of drip irrigation systems have literally disappeared from these systems and have been replaced by sprinkler.

(ii) Pests and disease

Fruit Flies, Red Palm mite and Acoushi ants remain the major problematic areas across the country. Strategies implemented in plantain management have shown an increase bunch weight to an average of 42 lbs in 2015 from 23 lbs in 2013. (data from PROPEL).

(iii) Weather

February and July presented farmers with two floods in the year. While January/ February floods only affected a small number of areas, The floods in July affected all coastal areas causing extensive damage to cash crops in regions 3,4 and 6. That was followed by hot, dry condition from August to the end of October which again prevented re-cultivation of affected farm lands.

Notifiable Pest Management

1) 24621 Coconut palms were treated for red palm mite on the East coast of Demerara between Mahaica and Hope Estate.
2) A total of 479 Acoushi ants' nests were fogged and a total of 7495 Packs of ants bait distributed to farmers across the country.
3) 4920 Coconut palms were treated for Army worm attacks in regions 5 and 6.
4) 125 Fruit flies traps were distributed to farmers in Orealla and Pomeroon. It should be noted that by no means this small number of traps can make a difference in the infestation levels of this pest.

Nursery Production

NAREI is responsible for nine nurseries located in Regions, 1, 2, 3, 4, 5, 6, 7, and 9. The Total number of plants produce is 177,414 for 2015.

National Tree Planting Exercise

The national tree planting exercise commenced on the 3rd of October with an opening ceremony at Bartica. However production of plants began in Mid-July with a total of 140,520 plants produced. At the end of December a total of 7131 plants were distributed that leaves 133,389 plants remaining for distribution in 2016.

Table 7 showed the number of plants produced and the number of plants distributed for the national tree planting exercise countrywide for 2015.

Table 7: Plant Production & Distribution, 2015

	2015 plant production			National tree planting exercise		
Nursery	**Budget**	**Actual**	**Difference**	**Produced**	**Distributed**	**Remaining**
Bartica	3000	22033	19033	6199	329	5870
Benaab	25000	17926	-7074	15225	117	15108
Charity	25000	18587	-6413	13862	2420	11442
Fort Wellington	5000	3062	-1938	10500	609	9891
Hosororo	15000	2603	-12397	15498	45	15453
Mon Repose	25000	43413	18413	29240	779	28461
Poudroyen	25000	41826	16826	20028	1224	18804
St Ignatius	12000	6486	-5514	18730	1591	17139
Timehri	25000	21478	-3522	11238	17	11221
Total	**160000**	**177414**	**17414**	**140520**	**7131**	**133389**

4.0 SOIL MANAGEMENT AND FARM MECHANISATION DEPARTMENT

Soil Chemistry Laboratory

The department conducted soil analyses and made fertilizer recommendations for 388 farmers, 4 UG students, 49 MSc. Students, 12 Mangrove and 18 GFC soil samples.

Establishing a Digital Soil Database for NAREI's map archives using Geographical Information Systems (GIS).

An inventory of hardcopy soil maps for Guyana located at NAREI was completed and the various state and NGO agencies with soil datasets were identified for gathering of datasets for national soil survey. A 'Land Resource Assessment for Agricultural Production in Guyana' will be conducted between January 2016 and April 2020. The main objective will be to create land suitability maps for crops at scales 1:100000 and larger for available agricultural lands in Guyana. The results of the assessment are to be used in user friendly geo-spatial downloadable applications that are compatible with handheld devices namely smart phones and tablets. This will enable users in field, to have access and identify soil types, land suitability for crops, soil limitations, and amendments needed for successful agricultural production.

5.0 LABORATORY SERVICES: ENTOMOLOGY, PLANT PATHOLOGY AND WEED SCIENCE

Services

Plant diagnostics process 75 samples for pest and disease problems and provided recommendations (Table).

Table: Common Pests Identified in 2015 and Recommendations Provided, 2015

Common Pests	Crops Affected	Recommendations
Fungal Plant Diseases Fusarium Rot and wilt. (*Fusarium sp*.)	Black eye , Cabbage, Red peas, Bread fruit, Watermelon, Pak choi Regions: 3,4	• Use of tolerant/ resistant cultivars if available • Application of systemic or contact fungicide when necessary. (Carbendazin, Kocide) • Practice field sanitation, crop rotation with non-host crops and provide good drainage.
Anthracnose (*Colletotrichum sp.)*	Bilimbi, Bread Fruit, Citrus, Watermelon Fruit, Cherry, Sweet Pepper, Hot Pepper Region: 3,4	• Practice crop rotation. • Use of contact fungicides, resistant varieties and improve sanitation conditions in fields.
Foliar leaf spot Cercospora Curvularia Alternaria	Cassava, Calaloo, Ochro , Cabbage, Banana Leaf Regions: 3,4,5	• Improve field sanitation • provide good drainage • Spray systemic fungicides • (Carbendazin/ Stratego) using recommended rate.
Black Sigatoka and Cordana (*M. fijiensis*)	Plantain and Banana Leaf. Region: 3, 5	• Practice deleafing, good field sanitation, good nutrition and apply fungicide only when needed.
Sooty Mold, Black Mold	Mango, Lemon, Guava, Cherry, Boulanger Region: 4	• Use of contact fungicide at the recommended rate.
Sclerotinia root rot	Sweet Pepper Region: 5	• Provide good drainage, apply soil fungicide (Kocide) at recommended rates, use

		tolerant/ resistant cultivars and practice crop rotation.
Fruit Scab	Guava, Cherry Regions: 4,3	• Sterilize equipment, use of Ridomil
Bacterial Plant Diseases Bacterial spots and wilt *(Pseudomonas sp.)*	Cucumber, Celery, Watermelon, Pumpkin, Coconut Plant, Tomato, Ochro, Plantain, Sorrel, Pak- Choi, Lettuce and Boulanger. Regions: 4,3	• Use clean seed material that are tolerant/ resistant. • Do not plant in contaminated soil. • Apply copper based fungicide/ bactericide (2-3 applications)
Ralstonia (corm rot)	Plantain* Region: 3	• Apply copper based fungicide/ bactericide (2-3 applications)
Bacterial Gummosis	Ornamental Christmas tree Region: 3	• Use clean seed material that are tolerant/ resistant. • Apply copper based fungicide/ bactericide (2-3 applications)
Insects Common insects were: Weevil, Red Palm Mite, Clown Beetle, Bess beetle, Phileurus Didymus, Wire Worm, Turtle Mites. Euonymus Scale, Snow Scale, Glover Scale, Brown Scale Lace Bug, Lance Fly, Anastraphta Fruit Fly Moth, Citrus moth, Sour-Sop wasp. Whiteflies, Mealy Bug, Gall Midge, leaf miner, Aphids, thrips Diamond Back Moth Black Soldier Fly Stink bug, Golden Tortoise, Sweet Potato Beetle, Beetle (*Marmarina maculosa*)	Crops mainly affected: coconut Region 2,3,4 Sour-Sop, Orange, Papaya, Grape fruit, Banana, guava fruit, pineapple, lime, cherry region 3, 4, 6 Plantain, Squash, Cassava, Pak-Choi, Calaloo, Bora, Sweet Potato, Hot Pepper, Ornamental Plant. Region 3,4, 2	• 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	Coconut leaf- Crinkled leaf of young coconut palms, Plantain- Nitrogen and Potassium deficiency, Lime- Nitrogen deficiency Region: 4	• Fertilize using micro-nutrients. • Use of potash and nitrogen

Parasitic Nematodes Reported were: Meloidgyne and Heterodera	Carrot, Tomato, Boulangar, Citrus Regions: 4,6	• Use of Vydate L, practice crop rotation, use of integrated crop management. • Use of tolerant/ resistant cultivars. • Fumigate soil if necessary.

6.0 NATIONAL PLANT PROTECTION ORGANIZATION (NPPO)

Introduction

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.

Inspection and Treatment Services

Agricultural commodities and regulated articles continued to be subjected to inspections prior to import and export to reduce the possible on 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 2015 at wharves, terminals and at bonds and warehouses to facilitate the imports. A total of one thousand six hundred and seventy one (1,671) import inspections were recorded. This number represents a forty-two (42) 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 2015 recorded an increase of approximately six (6) percent or six thousand nine hundred and ninety five 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 thirty three

thousand three hundred and ninety seven (3,397) or an increase of fifteen (15) percent over the corresponding period for 2014.

A combined total of four thousand five hundred and eighty four (4,584) flights were inspected at the two (2) International Airports (Cheddi Jagan and Ogle International Airports) for the year 2015. 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 sixty five (1,365) 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 2015 reflected a decrease by ten percent (10) in the number of inspections conducted on arriving and departing ships.

The NPPO continued with the inspection and supervision of treatment services within the rice sector. For the year 2015 a total of four thousand three hundred and twenty- seven (4,327) 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 six hundred and seventy-seven (3,677) Phytosanitary certificates were recorded as issued for the year 2015. This figure represents approximately one (1) percent increase when compared to the previous year. This is also evidence of exporters' compliance in meeting the entry requirements of trading partners and the export requirements of Guyana.

Table: Commodities Exported and Phytosanitary Certificates (PC) Issued during 2014 and 2015.

Commodity	Phytosanitary Certificates Issued	
	2014	2015
Rice	1,380	1300
Sugar	79	132
Lumber	1,089	1,178
Fruits and Vegetables	557	379
Sand	44	43
Wheat Flour	37	23
Other	177	401
Commercial PC	**3,363**	**3,456**
Non Commercial PC	**273**	**221**
Total PCs Issued	**3,636**	**3,677**

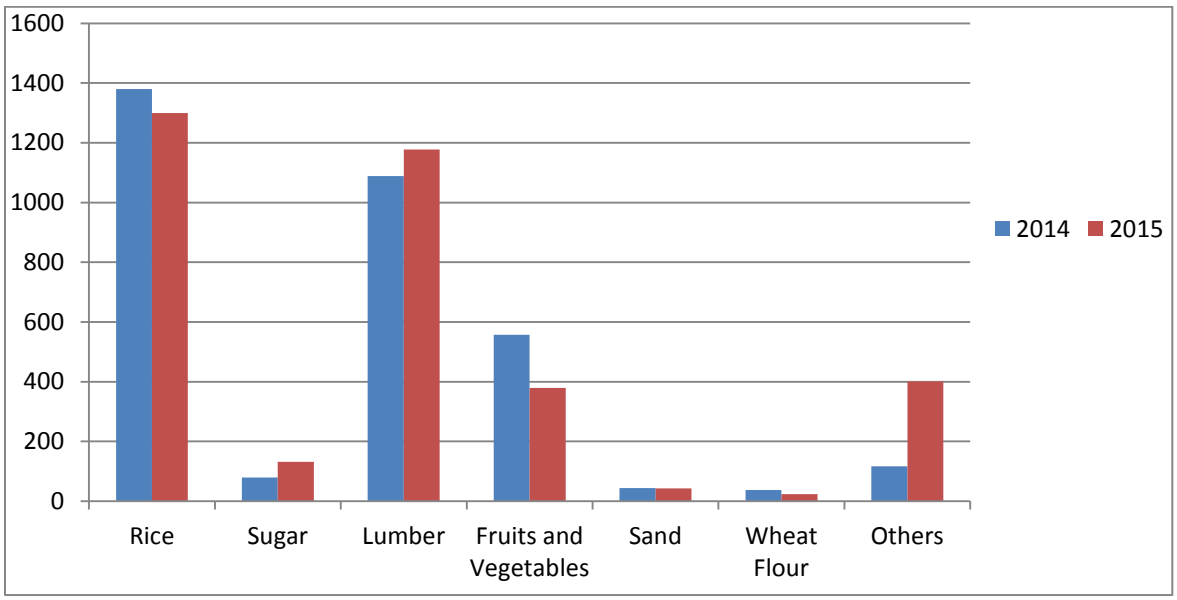


Figure : Issuance of Wood Packaging Materials Certificates

The total number of Wood packaging Materials Certificates issued for the year 2015 was sixty-four (64). A 83 percent increase over the total number of certificates issued in 2014.

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

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

Two hundred and thirty-six (236) such interceptions and or seizures were done for the period under review. This represents a 108 percent increase in interceptions and seizures activities.

Plant Protection Services

Surveys and Surveillance

Carambola Fruit Fly (CFF) & Mediterranean Fruit Fly (Med Fly)

The Team of the Plant Protection Services continued to dedicate its energies to the Carambola Fruit Fly program; through activities conducted within seven (7) Regions of Guyana, namely; 2, 3, 4, 5, 8, 9 and 10. The program saw the team focusing on detection of "CFF hot spots" for the first half of the year and the implementation of continuous control activities during the

second half. The effectiveness of this strategy will be determined during the first trimester of 2016 as the goal remains to control the spread with the intention of eradication.

Region 2

CFF activities executed within this Region continues to indicate the presence of the Carambola Fruit Fly concentrated along the banks Pomeroon River between the villages of Grant Opposition to Warapana. With the implementation of the Male Annihilation Technique as the backbone of the control program, the Staff of Region 2 distributed fiber board blocks soaked with Methyl Eugenol and Malathion on farms and residents along the banks of the Pomeroon river.

Region 3

Surveillance activities during the first half of 2015 indicated the presence of CFF on of the Island Wakenaam, Parika back to Vergenoegen and Canal 1. Even though the team distributed baits within all the aforementioned areas, attention was given to Canal 1, as the farm lands located within this area are very extensive giving rise to a grand variety of host fruits. Due to this vastness of farm lands times the large quantity of farms the team was unable to complete this mighty haul. It is intended to continue control activities in this area during the first half of 2016.

Region 4

Through tedious work and dedication the Plant Protection team has managed to contain the spread of the Carambola Fruit Fly within the known "Region 4 Hot spots"; Laluni, Kuru Kuru, and from Timehri to Garden of Eden. The team paid more attention to the area surrounding the Cheddi Jagan International Airport and ensured that traps and baits distributed were always effective. This lead to the implementation of "sheltered baiting stations". These sheltered bait stations (SBSs) are simply the same effective fibre board blocks under the cover of bucket tops, 5 gal or 2 litter bottles. The objective is to protect the blocks from natural elements in order to lengthen its effectiveness. Control activities were conducted within Laluni, Kuru Kuru, Hill Foot and from Timehri to Garden of Eden.

Region 5

To much surprise during first half of 2015 the team made a positive identification of the Carambola Fruit Fly within two villages of Region 5,namely; Mahaicony and Kingelly with one (1) and two (2) flies respectively. The team immediately introduced temporary control measures within both areas with the implementation of the Mass Trapping technique. All other areas/villages remained with a negative reading. The team also returned to conduct control activities within the said villages which resulted in negative readings during the month of November.

Region 8

The Plant Protection Services was able to extend its surveillance arm into the mining community of Mahdia. Several areas within and surrounding Mahdia were visited. Surveillance traps were distributed and awareness was brought to the residents regarding the importance of CFF. Inspection of fruits on site showed hardly any signs of fruit fly infestation. Continued monitoring are expected during 2016.

The hinterland villages of Region 8 were also visited with emphasis being placed on the villages of Bamboo Creek and Kanapang. Positive identification of CFF within these two (2) villages resulted in the immediate distribution of fibre board bocks and multiple Jackson Traps. These villages are in close proximity of the Brazilian boarder and correspond with the community of Uiramuta on the Brazilian boarder. It is intended that special efforts will be made during the work year of 2016 to bring control to the CFF presence within this Region through more frequent visits.

Region 9

Monitoring activity conducted within central Lethem and surrounding villages during the second half of the year resulted with all Jackson traps distributed within the villages reading negative of the Carambola fruit fly.

Region 10

A series of same day trips were made to Rockstone, numbers 47 and 58 villages within Region 10. In accordance with the strategy, the first series of trips were aimed at monitoring whilst the second were more focused on reducing the population of CFF through control activities (bait distribution). Carambola fruit flies were found at all three locations.

The 2015 CFF surveillance work programme was accomplished with the monitoring of 864 Jackson Traps, 136 McPhail Traps, the distribution of 6,434 fibre board blocks, 43 sheltered bait stations and the processing of 251 fruit samples.

Surveillance activities for the Mediterranean Fruit-Fly (Med-Fly) continued during 2015 with emphasis being placed on the environs of the International Airports, Supermarkets and Markets, Hotels and Guess Houses of Region 4. To date all traps read negative for this quarantine pest.

Pink Hibiscus Mealybug (PHMB)

The presence of the Pink Mealy Bug is currently restricted to regions # 2 and # 3 and in very low population densities. These areas for Quarantine and trade purposes have been designated Areas of Low Pest Prevalence (ALPP) for the pink hibiscus mealy bug. This classification allows Guyana to export agricultural commodities that are hosts to the pink hibiscus mealy bug.

Biological control continued to be the sole management strategy for the control of the Pink Mealybug. The parasitic wasp, Anagyrus kamali and the ladybird beetle, Cryptolaemus montrouzieri and continues to effectively manage the pest population.

Papaya Mealybug (PMB)

The NPPO continued with its passive surveillance programme for the Papaya Mealybug in key locations within regions # 3, 4, and 5. These regions are presently free of the papaya Mealybug. Monitoring of these regions will continue in the New Year to commence the process for the establishment of these regions as official Pest Free Areas (PFAs) for this pest in accordance with WTO/SPS and IPPC Guidelines, ISPMs #4 “Requirements for the Establishment of Pest Free Areas (PFAs).

Giant African Snails (GAS)

Passive surveys were conducted for the Giant African Snail (Achatina achatina) which continues to be a pest of economic and quarantine importance to Guyana and the Caribbean region. This pest is known to cause significant economic damage to crops and is present in some Caribbean countries such as Barbados.

Surveys were conducted at the various wharves within Georgetown and at the ports-of-entry. Guyana continues to be free of this pest.

Mango Seed Weevils

Passive surveys were conducted for the Mango Seed Weevil Sternochetus mangiferae (Fabricius) which continues to be a pest of economic and quarantine importance to Guyana and the Caribbean region. Guyana continues to be free of this pest. Sites visited during inspections included wharves, container terminals and bonds.

Red Palm Mite (RPM).

Given the established quarantine importance of the Red Palm Mite, this programme activity went on to shift its focus to a new level, that of the identification of Natural Enemy in the field. These activities were undertaken in Regions 3, 4 and 5 and were spearheaded by Mr. Farzan Hosein, TCDC Consultant, and FAO from Trinidad and Tobago. Overall observations revealed a wide distribution of two principal Natural enemies; the green lacewing(ceraeochrysa spp) and the predatory mite(Amblyseius sp). Leaflets samples were further collected and submitted to the Bio-control laboratory of NAREI where the final diagnosis was made.

The Plant Protection Services continued to conduct activities aimed at detecting and implementation of temporary chemical control of the RPM.

With this said, surveillance activities were executed in Regions 3, 6 and 10 (Rockstone, 47 and 58Village). The leaf samples collected were of a random order from different locations within the target areas. Leaflets were bagged, labeled and transported to Bio-control laboratory for analysis and confirmation.

Within Region # 3, a total of twenty-one (21) villages along the West Coast of Demerara were subject to detection activities. This resulted with the collection of 130 leaf samples which upon laboratory analysis were confirmed positive of Red Palm Mite.

Similar works carried out in Region 6, within twenty- three (23) villages were all negative for the RPM.

With regards to Region # 10 villages of Rockstone, 47 and 58, a total of twenty- one (21) samples were collected which all proved negative for the RPM.

Internal Quarantine measures were only conducted on the island of Wakenaam during this year.

These activities were facilitated by Officers of the National Plant Protection Organisation and Crop Development and Support Services in an effort to contain the pest on the islands until the official eradication programme can be implemented.

The NPPO outlined internal quarantine guidelines for movement of plants, plant products & regulated articles from Wakenaam and Leguan Island.

All palm and it's by- products were fumigated with Phostoxin tables for 72 hours before leaving the island.

Farmers were issued with an internal certification slip to verify that their produced were treated. A total of 1,557,088 dry coconuts, 59,222 brooms and 11,288 water coconuts were subjected to internal quarantine treatment on the island of Wakenaam.

Chemical treatment of the Red Palm Mite was conducted using spray application and injection application of pesticides. Abamectin were applied to coconut and Musa spp using a mist blower, while Monocrotophos was injected into the coconut trunk using a power drill at a 45 degree angle.

Treatment was carried out in Wakenaam, Leguan, Essequibo coast and Hog Island during 2014.

- Total of 23,418, 1,400, 85 and 82 trees were treated with Monocrotophos on Wakenaam Island, Leguan, Essequibo coast and Hogg Island respectively.
- 20 acres of plantain tress were sprayed with Abamectin
- 598 coconut palms were sprayed with Abamectin

Public awareness continues to be a main area within any programme conducted by the National Plant Protection Organisation, the RPM programme was no exception, residents of target areas continue to be educated, through talks and brochure distribution, about the importance of early RPM identification, appropriate treatment control, and most of all understanding the economic impact of the Red Palm Mite.

Certification Services

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 sixty one farms were visited for the purpose of certification for the year 2015. These farms are located within regions # 3, 4, 5 and 6 respectively. These were second audit visits for these farms which will continue in 2016 with the aim of certification.

Pest Risk Analysis (PRA)

The PRA's conducted in 2015 are shown in table below.

Table: PRA Activities Conducted for 2015

PRA Type	Commodity source	Import location /Destination	Commodity to be imported/exported	Status
Provide PRA Pest Data Sheet	Guyana	Antigua	Citrus	PRA Initiated, PRA information provided by the exporting country.
Provide PRA Pest Data Sheet	Guyana	Mexico	Rice	Requested information provided
Received information to facilitate PRA process	Suriname	Guyana	Banana	PRA initiated
Provide information to facilitate PRA process	Guyana	Grenada	Pineapple	Information provided to initiate the PRA process.
Provide information to facilitate PRA process	China	Guyana	Lumber	Awaiting information from China to start process.
Received information to facilitate PRA process	India	Guyana	Corn Seeds	PRA initiated
Provide PRA Pest Data Sheet	Guyana	Venezuela	Rice	Requested information provided

Training and meetings

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 thirty meetings were attended by NPPO Representatives both at National and International forums for the period under review.

NPPO Staff participated in a total of eighteen training activities held nationally and internationally for the year 2015

Public Awareness

Three hundred and thirty three (333) handouts and posters relating to farm certification and pest of quarantine importance were distributed to the general public for the year 2015. Six advertisements were place in various media houses to enlighten the general public on Quarantine Procedures.

Pest Diagnosis, Advisory and Laboratory Services

The Fruit Fly Laboratory 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 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 Republic of 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 and Mediterranean Fly scientifically acknowledged as the Bactrocera carambolae and Ceratitis capitata respectively. The FF laboratory also directs its some energies 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.

During the period under review, fruit samples were submitted from five administrative regions; 3,4,5,6 and10 for the purpose of assessing the fruit fly status within these geographic locations. Fruits that were investigated included; achee, bilimbi, carambola, cashew, cherry, douns, golden apple, grape fruit, guava, monkey apple, nooni, orange, passion fruit, pepper, plum, psydium, sapodilla, soursop, star apple, sugar apple, tamarind and whitey. The laboratory has seen a total of 23 entries recorded resulting in the examination of 251 individual fruit samples.

An analysis of the acquired data from the examination of fruit sample revealed the emergence of 1143 pupa and the evolution of 987 fruit flies; more specifically 506 Bactrocera spp, 460 Anastrepha spp, 0 Ceratitis spp , 21 Unverified.

Table: Fruit Fly Emergence Distribution throughout surveyed Regions for 2015 .

Administrative Regions	Pupa	*Anastrepha spp*	*Bactrocera spp*	*Ceratitis spp*	Unidentified *Spp*
3	306	248	14	0	0
4	816	191	492	0	21
5	0	0	0	0	0
6	21	21	0	0	0
10	0	0	0	0	0
Total	1143	460	506	0	21

The FF laboratory has recorded data that will be used to assess the fruit fly status throughout Guyana. The data accumulated thus far is preliminary and will be used as a guide for continuous research within this arena. From Table 1, it can be observed that Guyana's Agro fruit industry is mainly being affected by two fruit flies of different species; Anastrepha spp found in fruit samples collected from Regions 3, 4 and 6 and Bactrocera spp evolved from fruit samples originated from Regions 3 and 4.

From observation it can be noted that there was a greater percentage of Anastrepha spp found in fruits collected from Region 3 compared to that of Region 4 and the other regions, whilst on the other hand, Bactrocera spp was more dominant in fruits from Region 4 compared to that of the other Regions. However, it must be noted that these Regions were the areas where major sampling was done and still requires much investigation. Hence, the continuous investigation in these Regions and all other administrative district will be critical for economic development through the agricultural sector in Guyana.

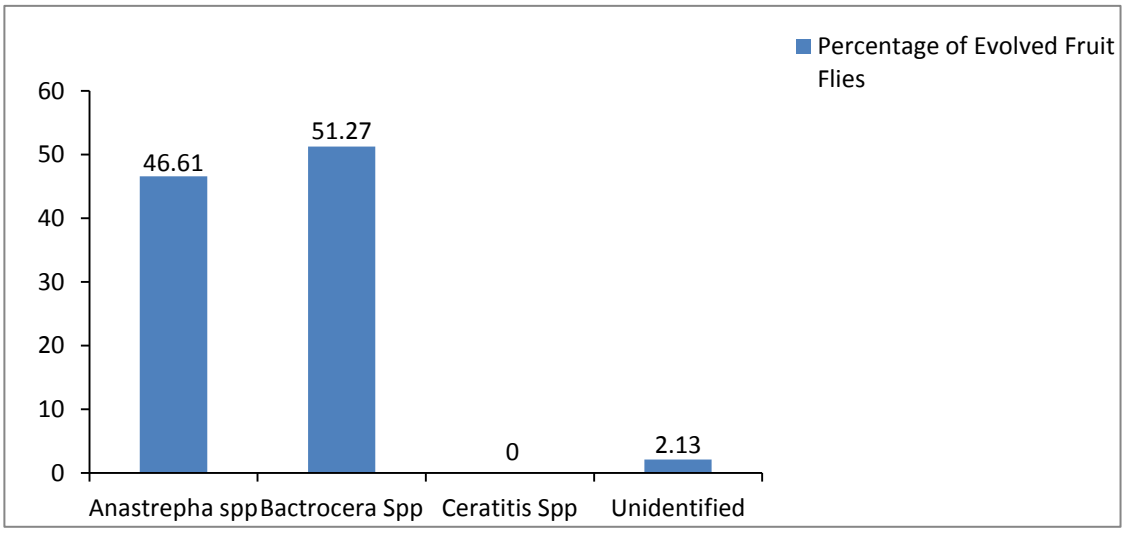


Figure: Displaying the Percentage of Evolved Fruit Fly Species for the year 2015

From the bar graph above (Graph 1), it can be recognized that even though the Carambola Fruit Fly (Bactrocera Spp) has shown a more over all dominance in fruit fly affected fruits within region 3 and 4, it presence is merely 4.66% higher than fruits affected by the local fruit flies of the Anastrepha Spp. It is to say, that the local species of fruit flies are doing just as much damage to locally produced fruits as the quarantine pest, Carambola Fruit Fly. The National Plant Protection Organization through the Fruit Fly Laboratory will endeavor during the work year 2016 to conduct a more comprehensive fruit collection program that will reflect more if not all the Administration Regions so that a scientific decision may be made in implementing a more generic approach to the control of fruit flies, with the ultimate aim of rendering support to farmers in the production of fresh fruits for trade and local consumption.

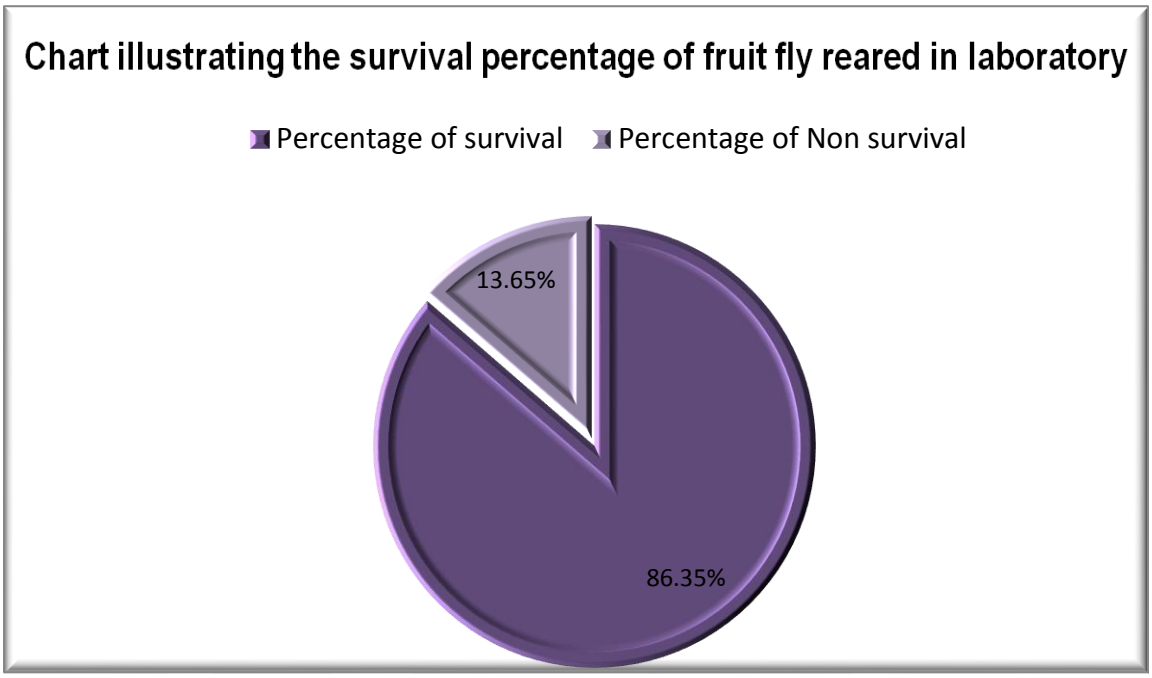


Figure: Illustration of the Survival percentage of fruit flies reared in laboratory during 2015

During the rearing process, it was found that the death rate of the fruit fly was found to be relatively high and this imposes a problem since it hinders the identification of all the fruit fly affecting specific fruits. However, it is assumed that the temperature of the environs and the sterility of the media in which the pupa was

The fruits that were found to be prolific hosts for Bactrocera carambolae and various being reared may have affected the maturation to adult. Hence; proposal has been made to implement measures to mitigate the possible adverse effect disseminated by these factors; such as monitoring the room temperature and humidity of the rearing facility by mode of RTM and Humidity gauges and the sterilization of media prior to rearing. This is with the aim of enhancing the survival rate of fruit flies reared and creating a standard structural environment for investigation. 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).

It is essential to recognize that this laboratory also aids in providing measurable service that contribute significantly to enhancing the phytosanitary measures being applied in relation to rice export. This is being 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 86 rice sample entries and 17 rice by-product entries which consisted of a total of 396 and 30 individual samples respectively.

7.0 THE INTERMEDIATE SAVANNAHS – EBINI 2015

1. Floyd Benjamin - Senior Research Technician
2. Kevin Gonsalves - Technician
3. Aaron Leitch Research Assistant (Up to May 2015))
4. Ray Imhoff - Manager Ebini Operations (from Nov. 2015)
5. N. Cumberbatch - Coordinator (Up to Oct. 2015)

Programme: Special Project under the direct supervision of the Chief Executive Officer

The year 2015 was one filled with challenges for the Research Station as it was one with high and some low achievements. The high achievements recorded were the success stories of the Orchard Fruit Crops that were exposed to "The protocol for the establishment of fruit Orchards in the Immediate Savannahs" that was developed during 2014 while some of the lows were as a result of aborted field trials coupled with the unpredictability of the pattern of rainfall which affected crop growth. This unpredictable weather pattern, however, did not prevent the Station from fulfilling its mandate for Grain Legume production which was established between the Ministry of Agriculture and NAREI by exceeding the required production target.

All equipment and machinery that the New Frontier Agriculture Company (a Brazilian company) will need in Ebini for the cultivation of their initial 100 acres of Soybean have arrived in Guyana via Lethem.

It should be remembered that this company signed a MOU with NAREI during 2014 to conduct research activities for soybean production at Ebini as a precursor for the development of a large scale agricultural complex in the Immediate Savannahs.

Rainfall Data for 2012-2015 in mm

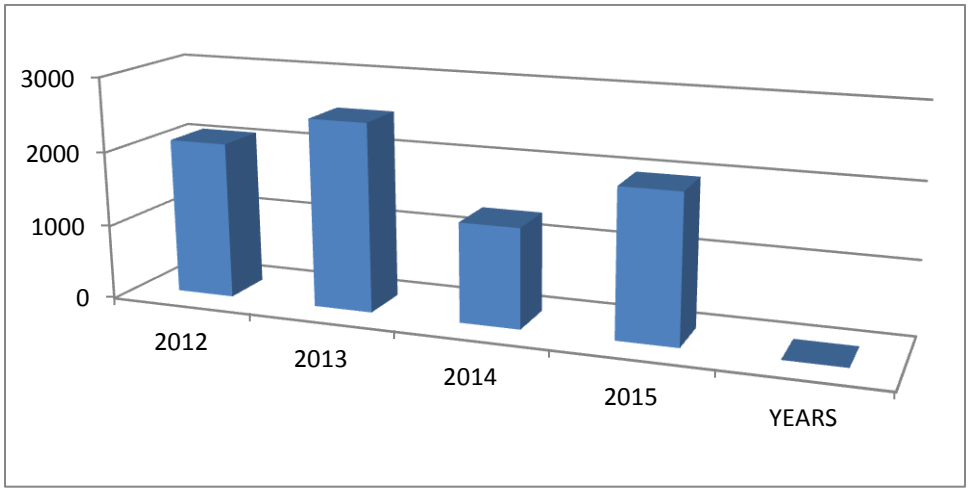


Figure: Rainfall data from 2012 to 2015 at the Ebini Research Station.

Please note that for 2014 the rainfall data for the month of October is unavailable.

Table: Monthly Rainfall Amounts for the Ebini Station, 2009-2015

Months	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**Total**
Rainfall (mm) 2009	178	103	79.1	140	64.3	251	213	184	59.5	160	45	126	1602.9
Rainfall (mm) 2010	158.2	64.4	154.0	290.7	623.2	243.8	353.8	143.6	151.7	41.4	242.6	108.4 1-16 Dec	2570.4
Rainfall (mm) 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

Rainfall (mm) 2012	153.3	231.8	61.4	324.9	240.7	220.8	379.4	144.0	62.8	80.1	110.4	84.6	2094.0
Rainfall (mm) 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
Rainfall (mm) 2014	123.6	181.2	4.1	92.7	130.6	309.1	131.3	41.0	22.2		156.2	140.7	1332.7
Rainfall mm 2015	263.3	102.3	99.0	123.0	273.9	225.7	371.3	200.00	72.5	1.8	112	129.3	1974.1

The table shows the monthly rainfall amounts recorded for the past seven years (2009-2015) at Ebini. Traditionally, the month with the most predictable rainfall was during the period May to July; however over the past five years only June and to some extent July seem to fit that pattern with the exception of May 2010, when the highest amount of rain was recorded. The table also shows that with the rainfall pattern between the months of September – March the growing of crops that require 120 days for maturity and indeed the orchard crops would be extremely difficult without irrigation. The only dependable period for crop production appears to be the period of May-August. There were 232 rainfall days for the year 2013 as compared with 209 for 2015.

Agricultural Systems at the Ebini Unit

The work programme of the Ebini Unit encompasses the work programme of a number of different Departments of the Institute.

The Agronomy Programme

The goal of the Agronomy Department of NAREI is to introduce new crop varieties, test improved varieties and promote the productivity of these crops by utilizing improved production systems.

The specific objectives of the seed programme of the Agronomy programme at Ebini are to:

1. Maintain the genetic purity of seed material.
2. Produce high quality seed material of selected crops.
3. Make available to farmers good quality seed at a reasonable price.
4. Provide a sustainable seed supply system.

Development of technological packages for crop production in the Intermediate Savannahs

The National Agricultural Research and Extension Institute (NAREI) in 2014 finalized the restructuring of its STRATEGIC RESEARCH AND DEVELOPMENT AGENDA (2013-2017) and beyond, therefore the research programmes of the institute had to incorporate as part of the programme, the development of technological packages for crops that are deemed important to the nation, and in keeping with the vision of the Government of Guyana and the mission of NAREI.

The development of these technological packages for crop production relates closely to the one of the objectives of the Institute, which states: to advise on, and develop appropriate systems to promote balanced, diversified and sustained agricultural development and optimize agricultural production through adaptive and investigative research.

Therefore in keeping with this trust and ensuring that the objectives as stated in the Schedule of Strategic Activities Jan 10 2014 (see STRATEGIC RESEARCH AND DEVELOPMENT

AGENDA 2013-2017) the Ebini Unit work programme for 2015 and beyond would reflect the strategy outlined and proposed. In all of the activities undertaken at the Unit, the operations would include but would be not restricted to the following:

1. Fertilizer studies
2. Monitoring of pests and disease
3. Studies related to the control of weeds
4. Studies related to the control of insects
5. Soil studies
6. Economic evaluation

The research activities at Ebini would therefore require the support of all of the departments of the Institute.

ORCHARD CROP PROGRAMME

The Horticulture Department

The high demand for orchard crops nationally has resulted in an increased need for seed to propagate these crops, this increased demand was the catalyst required for the rehabilitation of the Ebini Nursery Programme. Additionally, it is envisaged that there would be an increased demand for orchard crop type activities in the Intermediate Savannahs as well as the Berbice river district, as the demand for fruit to supply the processing sector increases. In this regard, a new orchard crop area was established at Ebini, and this development provided the opportunity to develop a protocol for the establishment of orchard crops in the Intermediate Savannahs during 2014.

The establishment protocol

The planting site

The soils of the savannahs are characterized as poor infertile acid soils, and therefore it is expected that the establishment of orchard plants on these soils would be problematic.

Therefore, the plant site was prepared by digging a hole about 2-3 feet deep and 2 ft square, the planting hole was then filled with about 4-5 kg of well weathered animal manure (at Ebini sheep/goat manure is used), additionally, about 250 gms of limestone was incorporated into the manure. The plant is then placed in the prepared site.

Planting only occur during the rainy season which gave the plant enough time to become established. During the dry period, water was supplied to the plants 3 times weekly; also during the dry period mulch was used on the roots to reduce moisture loss.

The Department of Plant Genetic Resources and Biotechnology

The orchard crop programme maintains some of the activities under the Plant Genetic Resources Department (PGR). As a consequence of the PGR programme, a project was developed to establish on-farm and out-station depositories of some specific crops. These include coconut, mango, citrus, guava, sweet potato and cassava.

The objectives of the programme are:

1. To establish basal collections of local mango varieties to serve as the national basal gene pool.
2. To establish basal collections of local coconut varieties representing the diversity of riverain and coastal ecologies.
3. To establish basal collections of local cassava and sweet potato varieties, and
4. To evaluate the growth and production of dwarf cashew varieties.

As part of the Orchard Crop programme, the PGR activities in the Intermediate Savannahs are highlighted and these include the establishment and maintenance of the repositories for the economic crops, namely mango, coconut and sweet potato. All plots were maintained and cleaned during the reporting period, the plants were fertilized with 12-12-17-2 fertilizer and organic matter was applied to the roots of the trees.

Mango

There are two blocks of mangoes planted at Ebini. There are 24 rows (varieties) in block 1 and 23 rows (varieties) in block 2; each mango row should have 5 plants of the same variety. In Table 7, the number in the mango row represents the number of plants in each row.

During the year all plants were clean, fertilized and limed and fruit was observed on some of the plants.

Table : Field Plan for the Ebini Mango Germplasm Plot, 2015

R	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
B1	5	1	4	5	4	4	5	5	5	5	5	3	1	1	2	1	1	1	1	0	0	0	3	1
B2	4	2	3	3	5	4	4	5	4	4	5	4	4	3	5	4	3	5	3	4	4	3	3	

Citrus

The Ebini Unit received the following plants during the month of May 2015 from the Citrus Company Guyana: Tangerine 12, Mandarin Orange 12 and Valencia Orange 12. These plants were added to the nursery and growth parameters were recorded.

The citrus nursery consist of Oranges, Limes, Rough Lemons and all plants were cleaned, fertilized and limed during the year.

The month of April 2015 was the last month for the monitoring of the establishment phase of the Nursery Collection and the following establishment cost has been computed:

Table: Establishment Cost for Ebini Orchard Crops

	ESTABLISHMENT COST				
	UNIT	$/unit	$/Plant	$/plant/yr	Total Cost
Land Preparation	Ha	$30,000.00	$521.00	$521.00	$75,000.00
Digging Pits manually	144 pits	6 man days @ $2000/day	$83.00	$83.00	$12,000.00
Planting	144 pits	6 man days @ $2000/day	$83.00	$83.00	$12,000.00
Lime	250g/plant	$1500/45kg	$8.00	$8.00	$1,152.00
Cost of Plant 1.Avocado $200.00 2.Avocado (G) $260.00 3.R. Lemon $200.00 4.Guava $100.00 5.Soursop $100.00 6.Go. Apple $500.00	1. 24 x $200 2. 9 x$260 3. 48 x $200 4. 24 x $100 5. 31 x $100 6. 8 x $500	$26,240.00	$182,00	$182.00	$26,240.00
Manure	5 kg/plant	$500.00/20kg	$125.00	$125.00	$18,000.00

Establishment Total			$1,002.00	$1,002.00	$144,392.00
Operating Cost					
Manure	5kg/plant	$500.00/20 kg bag	$125.00	$250.00	$36,000.00
Weeding	Entire orchard 2 times /mth	$30,000.00/mth	$208.00	$2,500.00	$360,000.00
Pest Control	Twice/mth	$3000,00/litre	$7.00	$83.00	$12,000.00
Circle Weeding	Each Plant	2 man days @$2000/day	$333.00	$4,000.00	$48,000.00
Fertilizer 12:12:17:2	250g/plant	$7500/45kg	$42.00	$84.00	$12,000.00
Lime application	250g/plant	$1500/45kg	$8.00	$16.00	$2,304.00
Irrigation	3800 litre/mth	$30,000.00	$208.00	$625.00	$90,000.00
Pruning etc	2 times /yr	$10,000.00	$69.00	$139.00	$20,000.00
Watering	36 times/yr	1 man day @$2000/day	$14.00	$500.00	$72,000.00
Operating Cost			$1,014.00	$8,197.00	$652,304.00
Total Cost			$2,016.00	$9,199.00	$796,696.00

The cost of production of an agricultural venture or project is critical to its long term survivalability and it also gives a fair indication of the viability o the project, more so, if the project is located in a rural or hinterland community or, in the immediate savannahs. In these locations the cost of supplying inputs as well as the cost of inputs could be more expensive than those of other favouable location.

Because of the length of time of the venture, only the establishment and operating variables for the first year of operation were taken into account. Based on the expected yield of the plants in

the Orchard as well as the cost of the fruits, it appears that the venture could be a financial success; however, yield and as well as profit were not considered in this exercise.

The number of plants in the collection for which this exercise was undertaken was 144 and the overall size of the collection site is approximately 5 ha.

The cost of capital items were not taken into consideration, however, the cost of providing the inputs and the labour cost for the input were taken into account.

Coconut Depository

The coconut programme at Ebini was part of a germplasm conservation programme funded by the United States Agency for Development (USAID). During the reporting year, plants continued to show signs of being productive. The collection was increased from 419 plants in 2014 to 467 plant during 2015 as a result of the collection of 48 plants from the National Service location at Kimbia. The 48 collected plants comprised of 24 varieties (12 classified as being good for water purposes and the other 12 for Copra production. This classification was based on taste of the water, size of the nuts as well as the thickness of the Kernel.

Once again cows from the Rising Sun Farm broke into this collection and severely damaged some plants. However, the plants were replaced after another collection exercise was undertaken to the Kimbia location.

During the month of July 2015, the collection of Coconuts that was obtained from the Pomeroon River during 2010 begun to fruit. The grass in this plot was controlled by using Roundup: The grass was first cut with the brush cutter and then sprayed with roundup - this system showed a sign of acceptable weed suppression as apparently the non-structural carbohydrate source of the grass was affected by the cutting and the weedicide furthered suppressed the growth of the grass.

Once every 6 months the 12:12:17:2 fertilizer was applied to the coconut plants at a rate of 300g/plant while circle weeding was done on a required basis.

During the months September/October 2015 the coconut collection probably experienced its toughest challenge for 2015 as only 74.3 mm of rainfall was recorded as compared to 126.1 mm, 142.9 mm, and 396.7 mm during the years of 2013, 2012 and 2011 respectively. Rainfall information for October 2014 is unavailable. Consequently, sections of the Savannahs were under fire during September/October 2015 and, eventhough the coconut collection was threatened, the fire-breaks prevented a catastrophe from occurring.

Table: Field Plan for the Ebini Coconut Germplasm Plot, 2015

Rows	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Plot 6**
Plants /plot						
1	5	5	1	4	5	5
2	3	Nil	4	Nil	5	5
3	5	1	Nil	5	5	5
4	5	4	5	4	5	5
5	4	5	5	3	5	5
6	5	5	Nil	Nil	5	5
7	2	4	4	5	5	5
8	3	1	4	4	5	5
9	5	4	Nil	1	5	5
10	Nil	5	5	5	5	5
11	5	5	5	5	5	5
12	4	5	5	Nil	5	5
13	5	5	4	5	5	5

14	2	5	4	4	5	5
15	1	5	Nil	Nil	5	5
16	4	5	2	2	5	5
17	2	5	1	5	5	5
18	Nil	5	Nil	4	5	5
19	2	5	5	5	5	5
20	5	5	4	Nil	5	5
21	5	5	5	5	5	5
22	5	5	5	5	5	5

Commercial Seed Production

The Ebini Unit is one of the national repositories of orchard and other crop types; one of its principal tasks is to act as the primary seed production unit for NAREI. The unit planted for commercial seed production purposes cowpea Minica 4(red pea) and California 5 (black eye pea), corn (Pioneer and CARDI C-001), soybean. These seeds are used for increased agricultural production as well as to ensure that adequate seed material is available for the various Government of Guyana programmes. The seeds produced at the unit were transferred to the Mon Repos Unit for storage and distribution and also to the farming communities within the Berbice River.

Additionally, NAREI was the signatory of a Service Agreement between the Ministry of Agriculture and NAREI. This service agreement which was signed by the Minister of Agriculture and the CEO of NAREI on 25 February 2014 relates to the effective management of NAREI in the provision of services.

In section 3.12 Priority Indicators. The service activity targets anticipated that the Institute contributes to the sector a total of 1000 kg of red pea seed and 500 kg of corn seed among other crops. Table 8 shows the type and amount of seed the Ebini Unit produced and supplied during the reporting year.

Table : Commercial crops planted at Ebini for seed regeneration, 2015

Crop Type	**Target (kg)**	**Seed produced (kg)**	**Comment**
Cowpea Minica 4	1000	1263	
Black eye pea	100	157	Cleaned seed 119 kg
Corn	500	1400	
Peanut	Nil		

8.0 MANGROVE RESTORATION AND MANAGEMENT DEPARTMENT

8.1 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, 2015 in the execution to its 2015 programme of works and mandate to restore, protect and manage coastal mangrove ecosystems.

8.2 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 cycles 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.

8.3 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.

8.2 STATUS OF INTERVENTIONS (1 JANUARY 2015 TO 31 DECEMBER 2015)

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

The Department 2015 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.

Fourteen persons (rangers, VMAC members and tour guides) participated in the Conservation Training curriculum "Mangrove Biodiversity and Ecosystem". Due to issues associated with internet connectivity and work schedule, only Unit 1 of the 5 units published was completed. However, participants have the option to complete the course on their own providing they have an internet connection.

Community tour guides and rangers benefitted from further training to improve their presentation and community skills through participation in a training program funded by Caribbean Aqua-Terrestrial Solutions and implemented by Iwokrama. Training also included birding and provided an opportunity for community tour guides associated with the newly established Mahaica River Tour to interact and learn from the Mangrove Heritage Trail Tour guides.

Staffing compliment was broken for three months with the resignation of the Wellington Wellington Park ranger. Mr. R. Medford was recruited and engaged in November 2015. Mr. R. Thom, Ranger with responsibility for Villages # 6 to #12 West Coast Berbice retired on 31st December 2015. There has been some difficulty identifying a suitable replacement in this area.

In preparation for the completion of a study "Measuring Growth Rates and Carbon Sequestration Potential in Planted and Successional Tropical Plants Using Unmanned Aerial Vehicles", the Department's Monitoring/GIS Officer benefitted from a training session on the use and operation of UAVs. The training focused on UAV operation, assembly and maintenance. Implementation of the research project is scheduled to commence January 2016.

During the year the Department provided input into the preparation of a coastal engineering manual developed by the Ministry of Public Infrastructure, Sea and River Defence Division. The Manual provides appropriate practical guidance for application of methods and techniques about the design and implementation of coastal engineering projects. Chapter 6 of the Manual provides information on the importance of natural flood protection systems along Guyana's coast and river banks and their relevance to the shore zone management process. Substantial focus is placed on mangrove forest. The Department Engineer and Monitoring Officers participated in a training program on the use of the Manual in December 2015.

Capacity building was facilitated through participation of the Project Coordinator and Engineer in a Risk Identification and Communication Workshop facilitated by IICA in Paramaribo in November 2015. The workshop provided an opportunity for participants to better understand how to identify risks and take steps to risk mitigation and adaptation. This workshop also afforded an opportunity for the Department to present the work being done in Guyana to restore its coastal mangroves as part of climate change adaptation.

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

Mangrove GIS Monitoring System: GIS is an important tool used to monitor changes over time and design restoration and management plans. The activities during 2015 focused on updating the GIS database and creation of new datasets based on monitoring reports and the results of interventions.

Main activities completed during the year:

- Social mapping of communities in Region #3 showing all the social groups within the villages. The results of the social mapping were the identification of location of key social centers and their relationship to the coastal zone. This information was used to develop a targeted community awareness plan.

- Mapping Spartina grass planted sites completed during the year as part of the technical support to the Community Based Mangrove Management Project implemented by local NGO GUYWID.
- Updating of the GIS monitoring data base with new datasets of boundaries for NDC villages from Regions 3, 4, 5and 6. New datasets included, planted spartina grass sites, pre-existing infrastructures (physical landmark features), elevation data, ranger monitoring points and new engineering structure.
- Participation in GIS day held on November 18th 2015 at the University of Guyana. GIS day targeted secondary schools students across Region#3 and #4 and provided an opportunity for the students to learn about the science, technology and its application in the geospatial field.
- A review and documentation of the literature on the relationship between the development of coastal mud banks, coastal infrastructure, shoreline type and mangroves to aid in future planning of restoration activities. The literature will be used to prepare a project proposal to map the dynamic cycle of mud banks and track their movements.

An important aspect of the GIS monitoring system is the web-based application which was designed to provide stakeholders which a platform to view the status of coastal mangroves and share information with partner agencies across the internet platform. However, this aspect of the system has experienced a number of set-backs due to connectivity issues which has resulted in the application not being accessed. Solutions to the problem were investigated and recommendation to utilize the ArcGIS Online platform was identified as the most suitable option. This option will be further investigated for implementation in 2016.

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 table below provides an overview of the sites monitored during the year. Monitoring parameters collected at each site informed detailed reports on the impact of the restoration intervention.

Site Reference	Site name/ Location	Restoration intervention	Date implemented	Monitoring scheduled 2015	Date monitored
Region #2					
R2-LIM-M001-000-JUL2013	Lima	*Avicennia germinans* seedling planting Spartina grass planting	2013	Time 0+18 Time 0+24	19-24th June 2015 11-12th and 19 -22nd Dec. 2015
Region #4					
R4-VBF-M001-000-JUN2011	Victoria	Geotextile breakwater Spartina grass planting Promotion of natural recruitment	2011	Time 0+18	5-6th February 2015
R4-HPE-M001-000-AUG2010	Hope	*Avicennia germinans* seedling planting	2011	Time 0+12	6-9th Feb. 2015
R4-GRF-M001-000-JUN2011	Green Field	*Avicennia germinans* seedling planting	2012	Time 0+24	26th Aug. 2015
R4-LUS-M001-000-AUG2014	Lusignan	*Avicennia germinans* seedling planting	2014	Time 0 Time 0+3	29th April to 3rd May 2015 11-14th Sept 2015
R4-NTZ-M001-000-DEC2014	Nooten Zuil	*Avicennia germinans* seedling planting	2014	Time 0 Time 0+3	24-27th April 2015 25 -27th August 2015

Site Reference	Site name/ Location	Restoration intervention	Date implemented	Monitoring scheduled 2015	Date monitored
Region #5					
R5-V68-M001-000-JUL2011	# 6-8 Village W.C.B.	*Avicennia germinans* seedling planting	2011	Time 0+24	29th Aug to 3rd Sept. 2015
R5-V68-M001-001-JUL2012	# 6-8 Village W.C.B.	*Avicennia germinans* seedling planting	2012	Time 0+30	30th Sept. to 4th Oct. 2015
Region #6					
R6-WPK-M001-000-JUL2011	Wellington Park	*Avicennia germinans* seedling planting	2011		
R6-WPK-M001-001-JUL2012	Wellington Park	*Avicennia germinans* seedling planting	2012	Time 0+30	23-27th Oct. 2015
R6-WPK-M002-000-JUL2012	Wellington Park	*Natural recruitment*	*Natural recruitment*	Time 0+30	24-27th Oct. 2015

Table : Sites monitored and monitoring schedule

An analysis of the monitoring data collected showed varying degrees of growth between sites.

Lima – a case of successful planting with extensive natural regeneration

Planted mangrove seedlings at Lima on the Essequibo Coast showed outstanding growth rates. This site showed fast growth rate of planted seedlings and substantial natural recruitment as the planted seedlings produced seeds and supported sediment accretion that facilitated new natural regeneration.

In addition to seedling planting, restoration intervention at the Lima site included planting of spartina grass. Planted spartina grasses have extended significantly further supporting soil consolidation and natural recruitment.

Figure: Lima restoration site - growth of mangroves and changes to site from 2014-2015

Tree heights at the site ranged from 1.6m to 16.8 meters.

Figure: Showing varying height of trees at the Lima site

Substantial natural recruitment recorded seaward of the restored forest as a result of the availability of seeds and sediment accretion.

Figure: Natural recruitment of black mangrove seedlings at Lima restoration site

- ***Lusignan and Nooten Zuil – a case of unsuccessful planting***

The Lusignan and Nooten Zuil restoration projects were completed during 2014 in collaboration with a project funded by the GEF Small grants programme and executed by GUYWID. The sites were selected based on elevation assessments completed prior to intervention which indicated that the site elevation was suitable to support restoration. Mangrove seedling planting was selected as an appropriate intervention given that nursery seedlings were readily available.

Time 0 monitoring completed at the sites indicated a high mortality rate at both sites. This was as a result of significant changes along the shoreline which caused seedlings to be eroded as the sediments were not consolidated. During the period, Guyana along with the rest of the Caribbean experienced significant sargassum invasion along the coastline. These monitoring sites experienced sargassum invasion and the impact of the sargassum is a factor that must also be considered in the low survival rate of planted seedlings.

The monitoring photos below illustrate the significant changes to the Lusignan site during the year.

Figure: Lusignan Site Jan 2015 - planted seedlings present and appear healthy

Figure: Lusignan Site February 2015 - planted seedlings present and appear healthy

Figure: Lusignan Site March 2015 – Sargassum along the shoreline at the site

Figure: Lusignan Site May 2015 – no visible signs of planted seedling, visible changes to condition of mud along the shore line

- ***Village #6 – a case of successful restoration and extensive natural succession***

Monitoring of the Village #6 West Coast Berbice restoration site indicates that this site has great potential to expand both seaward and further along the coast. Substantial natural regeneration continues to occur at the site with natural regeneration of both mangroves and spartina grass reaching as far as Village No 2 which is approximately 2.8 kilometers east of the initial restoration area. The success of this site is however continuously threatened by extensive grazing of livestock by residents. Interventions implemented during 2014 which sought to restrict the grazing proved ineffective as residents vandalized the gate erected at the main access bridge. Alternative measures will have to be investigated to ensure that the site is successfully restored to serve its coastal protection function.

Figure : A section of the natural regeneration at Village No. 7, WCB

Figure : Natural regeneration of mangroves and spartina at Village #2, WCB

ENFORCEMENT

At the end of 2015, nine mangrove rangers were engaged to monitor and protect mangrove forest areas from grazing by cattle, goats and disturbance by other human activity (e.g. fishing boats and illegal harvesting of mangrove wood). 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 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: List of sites 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. Andrews	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	R. Thom	Woodley Park to Number 6	3.6km	5
	Region #6			
10	R. Medford	Kilmarnock to Epson	10.3km	5

Based on analysis of monthly reporting by rangers, the following table presents a summary of the notable observations recorded (negative and positive).

List of major issues report by rangers

Range	Major Issue reported
Region #2	
Essequibo Coast	Grazing is challenging
Walton Hall to Anna Regina	Natural recruit extensive at planted site
Shiva Balroop	Structure completed at Devonshire Castle and Walton Hall.
	Structure at Anna Regina needs repairs due to destruction from heavy wave action
	Sargassum invasion
Region #3	
West Bank Demerara	Extensive erosion occurring on the West Coast of Demerara from Rotterdam to Windsor Forest continues.
No ranger – monitored by Monitoring Officer	
Leguan Island	Cutting of mangrove reported
Donald Ramlakhan	Erosion occurring
	Community involvement with VMAC extensive
	Natural recruit of Spartina
	Sargassum invasion
Region #4	
Mon Repos/Montrose	New growth observed
Colis Andrews	Erosion occurring
	Mud build up due to presence of rubble mould groyne
	Sargassum invasion
Lusignan/Strathspey	Fish remains being dumped at Lusignan
Luan Gooding	Extensive erosion at planted site
	Sargassum invasion
Golden Grove/Belfield	Increase erosion occurring at Belfield end
Raymond Hinds	New growth within Spartina planted area
	Reduce mooring by fisher due to public awareness by ranger
	Sargassum invasion
Nooten Zuil/Anns Grove	New growth observed
M. Persaud-Itwaru (Jimmy)	Siting of different bird species
	Erosion occurring at Hope koker foreshore and Nooten Zuil planted site
	Sargassum invasion
Ann's Grove/Greenfield	Erosion occurring and plants being uprooted

P. Ragnauth (Kevin)	Issuing brochures to schools and community
	Grazing occurring
	Sargassum invasion
Region #5	
# 6-12 Villages, West Coast Berbice	Natural colonization of Laguncularia racemosa (white mangroves) occurring at Village #6
Richard Thom	Grazing of cattle and small ruminants
	Sane fence to prevent animal gazing was removed by member/(s) of the community
	Natural regeneration occurring at waterlogged area at Village # 12
Region #6	
Kilmarnock/Adventure, Corentyne Coast	Grazing occurring
Rawle Medford (Nov 2015)	Erosion occurring at outlet canal at Kilmarnock koker
Wellington Park/Epson, Corentyne	Biodiversity – nesting of various species of birds
	Remains of turtle on the beach
	Grazing
	Natural regeneration occurring

Figure: Sargassum invasion at LBI

COMPONENT 3 – COMMUNITY-BASED MANGROVE MANAGEMENT

COMMUNITY BASED MANGROVE MANAGEMENT

- ***Village Mangrove Action Committees***

At the end of 2015 there were eight Village Mangrove Action Committees in operation in Regions #2, to #6. This represents an increase by one from the previous year following the orientation of the newly established Leguan VMAC in November 2015.

The Department projected to establish two new VMACs during 2015; however this did not materialize as the stakeholders in the second location identified – La Jalouse/Novelle Flanders NDC- did not respond positively following a community meeting on the status of mangroves in the area proposed to form the volunteer group. Mangroves along the shoreline of the villages within the NDC have been rapidly eroding since 2014, and it is against this background that the Department identified the need to increase awareness about the cause of the erosion and encourage residents to support monitoring the effects. Given that residents were not encouraged to form a Volunteer group, awareness activities were completed by the Community Development Officer targeting local religious organisations and schools.

Membership of VMACs and their participation in awareness and community enhancement activities during 2015 was notably less than previous years. Members expressed a lack of interest given that they were not receiving any immediate tangible benefits. Members also identified the need to increase the youth membership of the VMACs and allocate funding for the execution of community projects similar to those implemented under GMRP.

The Anna Regina VMAC which was established in 2013 was the least performing group for the year. Due to the geographic challenges and the lack a strong leadership within the VMAC, the group only met once during the year. In order to correct this situation, the department has planned a four day training workshop in Anna Regina during the first quarter of 2016 to increase stakeholders' knowledge about the importance of mangroves and restoration activities on the Essequibo Coast. It is expected that on completion, new members will be identified to join the VMAC.

The following tables provide an overview of VMAC membership and activities completed during the year.

Table*:* VMAC Membership at the end of 2015

VMAC Name /Location	Number of Meetings held	Membership Dec 31, 2015
Region #2		
Anna Regina	1	3
Region # 3		
Leguan	1	18
Region # 4		
Mon Repos	1	3
Victoria-Belfield	3	3
Buxton-Friendship	5	10
Greenfield-Beehive	1	2
Region # 5		
Village # 6-8	5	8
Region # 6		
Wellington Park	3	9
Total VMAC membership		

VMAC Activities completed during 2015 and challenges

#	VMAC Name/Location	Activities	Issues/Challenges facing mangroves and VMAC
1	**Mon Repos**	▪ Presentation to participants of community Summer camp	▪ Garbage dumping ▪ Lack of membership
2	**Buxton**	▪ School presentations	▪ Erosion
3	**Village #6-8**	▪ Cleanup of mangrove compound ▪ Church presentation	▪ Grazing on foreshore
4	**Victoria**	▪ Enhancement of mangrove heritage trail tour ▪ School presentations	▪ Lack of participation
5	**Wellington Park**	▪ Church presentations ▪ School PTA presentation	▪ Grazing
6	**Greenfield/Beehive**	▪ House to house awareness – distribution of flyers ▪ Beach cleanup ▪ CDO home visits	▪ Grazing ▪ Garbage dumping ▪ Lack of interest

		▪ NDC officials field visit ▪ Contact database for garbage disposal service established	
7	**Leguan**	▪ House to house awareness-distribution of flyers ▪ Beach clean up ▪ Painting of community bus shed ▪ School presentations ▪ IT Centre cleanup	▪ Garbage dumping ▪ Cutting ▪ Grazing
8	**Anna Regina**	▪ House to house awareness	▪ Lack of participation

Community Action Plans (CAP) were developed for six VMACs based on issues facing the community and the management of its mangrove ecosystem. Action Plans were developed to address the main issues through public awareness and engagement. The implementation of the CAPs was however hindered by the poor participation of members in three of the six VMACs. The membership of the Wellington Park, Buxton and Village # 6-8 VMACs made notable efforts to implement their CAPs. Annex 1 provides a summary of the CAPs prepared for the six VMACS.

- ***Training & Capacity Building:***

Capacity building sessions were conducted with the newly established Leguan VMAC group. Members of the VMAC were exposed to three capacity building sessions:

- Presentations on the restoration, conservation and management of mangroves. This session included a review of the status of mangroves on the island and interventions used in mangrove restoration.
- Field identification of the types of mangroves found on the island
- Roles and responsibilities of VMAC members

The capacity of VMAC members to better understand the mangrove ecosystem challenges along the coast was further strengthen during a VMAC Exchange. VMAC members from Berbice (West Coast Berbice and Corentyne Coast) visited several sits on the East Coasts and participated in a one day session with their East Coast counterparts.

Mangrove Reserve Producers Coop Society:

During 2015 the department continued to provide technical and administrative support to the MRPCS which was formed under GMRP. The Coop is currently undergoing administrative changes with guidance and oversight from the Chief Coops Officer. NAREI's support during the year included funding for the completion of an Introduction to Bee Keeping course which was executed by the Coop to encourage more persons from the community to engage in apiculture. The Coop was also supported in their participation at the Linden Expo to market their products and the development of a proposal to access a community empowerment grant through the Ministry of Communities. This grant was awarded to the Coop in December 2015 and will be implemented in 2016.

Figure: Leguan Community awareness - mangrove species identification

Figure : VMAC participation in Clean Up the World Weekend 2015 – Kitty Beach Clean up

Figure: VMACs participation in World Environment Day 2015 – Greenfield Beach Cleanup

Figure : VMAC Exchange and capacity building

Component 4 – Research and Development of Guyana's Mangrove Forest

The Department identified five research projects for completion during 2015. These projects were identified from the GMRP research gaps and priority research areas report. The following research projects were initiated by the department and will be completed in 2016:

Project 1: Understanding of the potential for low cost engineering infrastructure to assist in the recovery of mangrove at field sites.

Status: Data collected on the impact of structures. Additional data to be collected during 2016 and analyzed to provide a comparative assessment of the different coastal infrastructure interventions.

Project 2: Overall understanding of the relationship between development of mud banks, coastal infrastructure, shoreline type and mangroves, a literature review

Status: Review of available literature completed. Design of proposed project for Guyana's coastline to be completed during 2016

Project 5: Long term understanding of the potential of trials Spartina brasiliensis as an alternative to traditional mangrove restoration techniques using mangrove seedlings

Status: Preliminary data collected and analysed with support from German Intern Student Aeneis Wild. Collection and analysis of additional field data to be completed by the department during 2016. Final research report to be completed 2016.

The other two research projects identified (Linkages between detritus and coastal fish stocks and Cost benefit analysis of mangrove restoration initiatives) were submitted to the University of Guyana as a call for proposal from Final Year students. However there was no interest in the topics by students. University Students are however completing research in other areas

related to Guyana's coastal mangroves which is being supported by the department and is expected to be completed in 2016.

COMPONENT 5 – MANGROVE PROTECTION AND REHABILITATION

Site assessment and evaluation is a critical element to any successful restoration intervention. One of the critical elements completed during site assessments is elevation surveys. Elevation surveys are conducted to ensure that a site selected for mangrove restoration through seedling planting has the adequate elevation suitable to withstand the action of waves and other natural elements. This is also used as one of the parameters for monitoring to assess changes over time. The results of these surveys indicated that there were limited sites available for restoration through seedling planting. As a result planting mangrove seedling was not considered as a viable intervention for the 2015 program.

Mangrove restoration activities completed during 2015 focused on the use of Spartina grass and coastal infrastructure as interventions to promote and encourage sedimentation and natural regeneration.

Spartina Grass Interventions

The Spartina grass trails were completed in collaboration with GUYWID as part of the implementation of the Community Led Mangrove Restoration Project. The Spartina grass planting was conducted during the period February 18, 2015 to June 19, 2015. Eight thousand and thirty eight (8,038) shoots/plugs of grass was planted at locations in Region #2 and Region #4 across five sites in an area measuring a total of 950m in length.

Table below shows the planted sites, number of grass shots planted.

Table : *List of Spartina Planting sites*

#	Location/Site Name	Amount of Shoots Planted	Remarks
	Region #2		
1	Walton Hall	1365	Plantings were negatively affected by erosion and Sargussum
2	Devonshire Castle	4260	Extensive expansion growth in planted grass
3	La Belle Alliance	655	Extensive expansion growth in planted grass
	Region #4		
4	BV/Triumph	1758	Plantings were negatively affected by erosion and Sargussum

Spartina grass planting was implemented as a means to improve soil elevation and consolidation, thereby improving the conditions for restoration through natural regeneration. The grasses planted at the four locations mentioned above during the reporting period have had mixed fortunes. While the grass planted at BV/Triumph and Walton Hall were affected by heavy waves and Sargassum inflow, the grass planted at Devonshire Castle and La Belle Alliance have been more resilient to the Sargassum inflow and are striving well and have aided in natural regeneration process of mangrove seedlings.

Figure : La Belle Alliance Spartina planted March 2015

Figure : La Belle Alliance Spartina August 2015

Figure Devonshire Castle Spartina May 2015

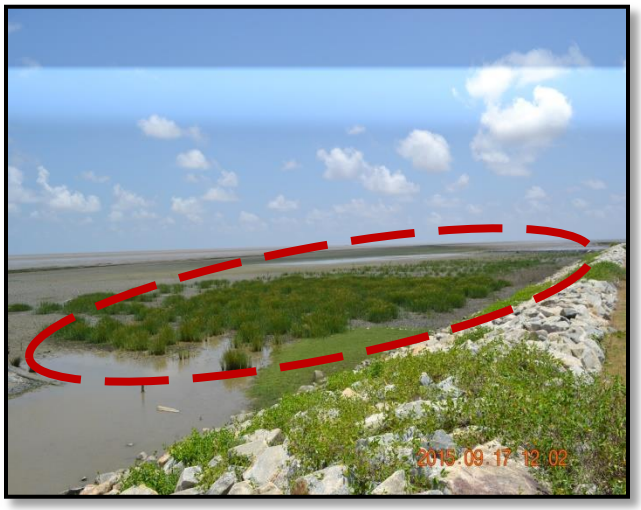
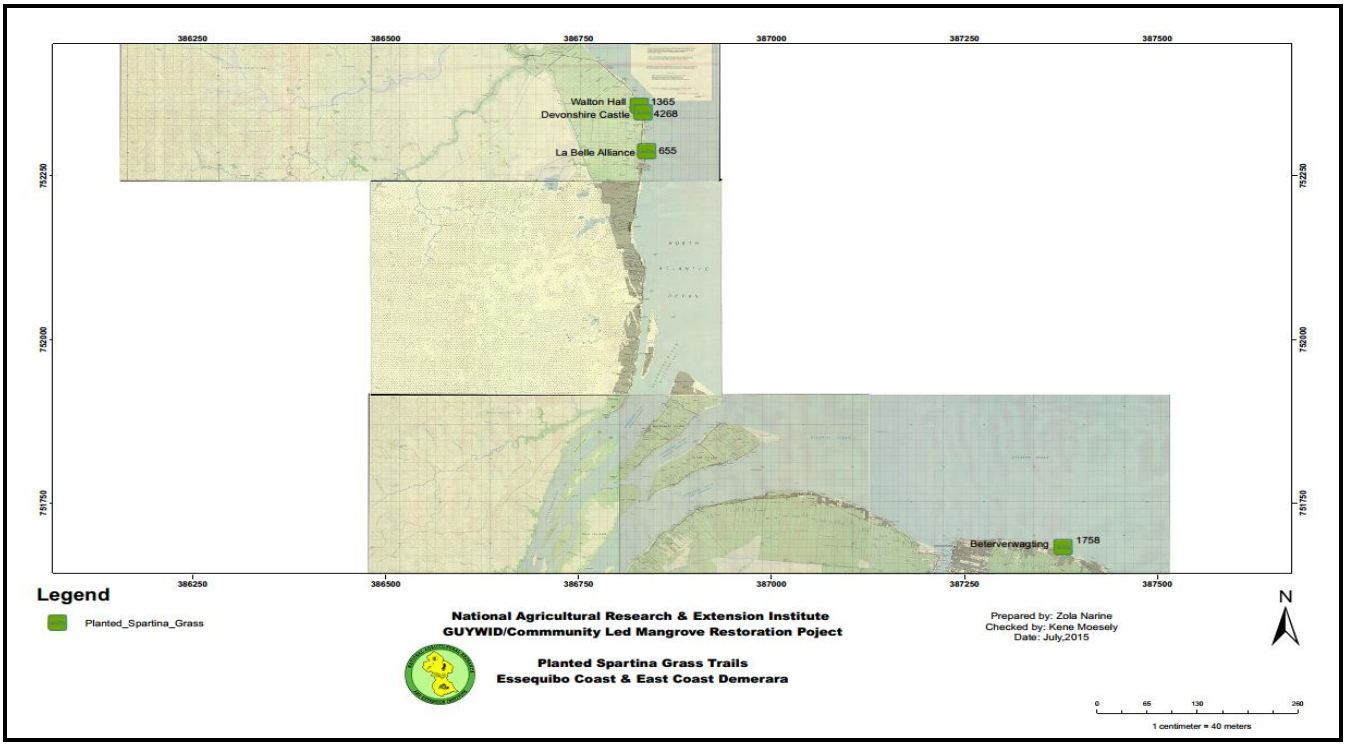


Figure: Devonshire Castle Spartina September 2015



Map 1 Spartina gras planting sites

Coastal Engineering Interventions

The introduction of coastal engineering structures contribute significantly to mangrove restoration activities by curbing wave action and other coastal processes promoting an enabling environment to facilitate mangrove colonization. Coastal engineering interventions executed during 2015 included repairs and maintenance to structures and the construction of a bamboo brushwood dam at Walton Hall on the Essequibo Coast.

Completion of new structures

Bamboo Brushwood Dam groyne, Walton Hall, Essequibo Coast

The Walton Hall Bamboo Brushwood Dam was completed in December 2015.

Walton Hall is protected by man-made sea defense structures i.e. seawalls and earthen dams. 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 foreshore is neither level nor stable since the mud particles are not allowed to consolidate properly due to wave impacts.

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. This project was set out to be completed in two phases: Phase 1 construction of a 100m bamboo groyne in 2015 and phase 2 Construction of 165m bamboo groyne in 2016.

A geotechnical was completed to provide data regarding sub-surface soil characteristics of the Walton Hall foreshore as it is expected to serve as the primary foundation to the structure. The information of the soil shear strength among other parameters obtained from this geotechnical investigation allowed for moderate variation to the original design of the structure and facilitated a revised and enhanced approached of the construction methodology.

The brushwood dam assembly is intended to act as a groyne to reduce wave energy, water velocity and current and encourage sediment accretion. The intent of the bamboo structure is to have a low cost, easily constructed, temporary structure that will function in a similar manner to the roots of the mangrove trees and more traditional rock breakwaters.

Construction of the Walton Hall Brushwood Dam was awarded to Samaroo's Investment following a competitive bidding process and was completed on the 20th December, 2015.

Main observations of implementation approaches:

- In order to remain a "low cost" solution, the brushwood dams at Buxton and Anna Regina 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.

Figure: Competed Walton Hall Bamboo Brushwood groyne

- **Hydrologic Restoration, Wellington Park, East Berbice Corentyne**

The execution of hydrologic restoration on the foreshore of Wellington Park commenced 23rd December 2014 and was completed on the 20th January 2015. The project entailed the excavation of 400m of channels of varying width along the foreshore of Wellington Park.

The Wellington Park Hydrologic restoration project aims to restore 7.5Ha of shoreline at the site to mangroves by re-introducing tidal channels into the salt pan area at the site to restore the natural hydrology of the site. Vegetation of the area comprises of a small corpse of mature mangroves and extensive salt wort. Due to the high level of salinity and lack of routine tidal flushing in this area, partially impound mangroves and marsh will begin dying shortly without hydrologic restoration, as the one remaining connection to the sea is closing due to sand and mud movement inland from eroding Chenier and adjacent mud flat behind the planted mangroves. Thus, to ensure that the planting exercise and natural regeneration of mangroves is successful it is necessary to have the correct the site conditions. In Addition, it will provide protection to the foreshore Chenier, which provides a livelihood for communities.

Figure : Channel at Wellington Park completed as part of the Hydrologic Restoration

Maintenance

- **Detached Offshore Geo-tube Breakwater, Victoria, East Coast Demerara**

The geotube breakwater was constructed in December 2012. The structure was designed to protect the foreshore at Victoria and promote better mud levels and density by reducing the intensity of waves at the site.

A number of factors resulted in significant wear to the geo-tubes used to form the structure. These included poor storage of the tubes for a significant amount of time prior to installations combined with coastal processes at the site. The exposure of the structure to the environment present at Victoria has resulted in a rapid degradation of the chemical and mechanical make up of the structure. In July 2014 NAREI preformed the first set repair works on the structure in an attempt to maintain its design function. These included:

1. Patching of six tears on the tubes having 12' diameter
2. Stabilizing the geo grid to prevent abrasion as the grids were placed above the scour apron

3. Refilling the tubes using a gravity flow system

In July 2015 additional repairs were completed on the structure as a result of defects observed during monitoring. These defects, large tears on the structure and deterioration of fill ports, resulted in significant loss of fill material and subsequent loss in design of one of the tubes. Temporary repair works were completed on the structures to minimize any further damage.

Works completed included replacing five fill ports, patching long tears due to extensive abrasion with a combination of materials i.e. marine ply wood pasted and screwed together sandwiching the tears and covered with two layers of geo-fabric materials. Permanent works are set out to be completed on the structure in 2016 with great consideration being placed on establishing a cost effective solution to the rapid degradation of the structure which includes reinforcing the surface of the structure with double geo fabric layers sewed together and treated with an appropriate additive to ensure the surface of the structure remains secure for a number of years.

Figure 1: Section of repairs completed on Victoria Geo-tube breakwater

- **Bamboo Brushwood Dam, Buxton East Coast Demerara**

The Buxton Bamboo Brushwood Dam groyne field was completed in 2013 and measured a total of 463m. The design objective of the structure is to reduce wave action and promote sedimentation. Results of monitoring following the completion of the structure indicated that eight months after the completion of the structure the foreshore at Buxton started to show satisfactory improvement i.e. sediment build up, natural colonization of mangroves.

However, drastic changes in the oceanic processes at extreme high tide periods along the coastline of Guyana during August to December 2014 and poor soil shear strength of the Buxton site resulted in the displacement of the bamboo piles. Varying sub-surface shear strengths (in some cases piles were driven to depth of more than 20ft before reaching medium stiffness) resulted in the removal of the approximately 45% of the vertical piles, 100% of the infill bamboos, 50% of mud build up and a 100% of planted and naturally regenerated mangroves seedlings. Repairs to the structure aimed at maintaining its design function became critical and the first phase was completed in June 2015.

Works on the Buxton structure were completed with support from the Community Led Mangrove Restoration Project and included:

- Use of approximately one thousand eight hundred and fifty two bamboos ranging between 4-6inches in diameter and lengths between 18-25feet.
- Vertical bamboo piles were spaced at a minimum distance of 0.5meter apart.
- The bamboo fences were repaired beginning with the westernmost T-shaped groyne working from the accordant long shore section cross-shore fence followed by breakwater (head of groyne). The three T-Shape fences were revamped at the Buxton foreshore.

Figure : Repairs completed to Buxton Bamboo Brushwood Dam

COMPONENT 6 – INCREASE PUBLIC AWARENESS AND EDUCATION ON THE BENEFITS OF THE MANGROVE FORESTS

- **Mangrove Heritage Trail Tour:**

The Mangrove Heritage Trail Tour provides a unique heritage and environmental tourism product to local and foreign visitors as well and students. During 2015 the Tour received over 1,000 visitors from government agencies and organizations, foreign tourist, students and local NGOs and Alumni. They represented increase in traffic of 60% over 2014. Visitors were educated on mangrove forests preservation and conservation and the rich history of the villages that comprise the tour destination.

National and International Events:

- World Environment Day- celebrated with the East Coast VMAC groups. Several school presentations were conducted with schools located within the VMAC areas and a clean-up was completed at Greenfield beach.
- Clean up the World - VMAC groups participated in the global Clean up the World initiative. The East Coast VMACs collaborated with the Natural Resource and Environment Department in the clean-up of the Kitty Seawall.
- National Tree Planting Day- Seven out of the eight VMAC groups participated in National Tree Planting Day activities. One hundred and twenty two fruit trees - cherry, gooseberry, cashew, carambola, pomegranate, soursop, guava and lime – were planted in community spaces, schools and church compounds.

- **Sign Boards installation**

- Sign boards were installed to sensitize community on the importance of mangroves and to prevent adverse activity such as grazing and garbage dumping at Leguan.

- ***Video documentary***

- Video documentary was completed on the role and contribution of women in mangrove restoration in Guyana as part of a submission to UNFCCC Momentum for Change Lighthouse Initiative.

- **Other awareness platforms – social media**

➢ The department utilized social media – 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 962 likes by the end of December 2015. This represented an increase of 553 from January 1, 2015.

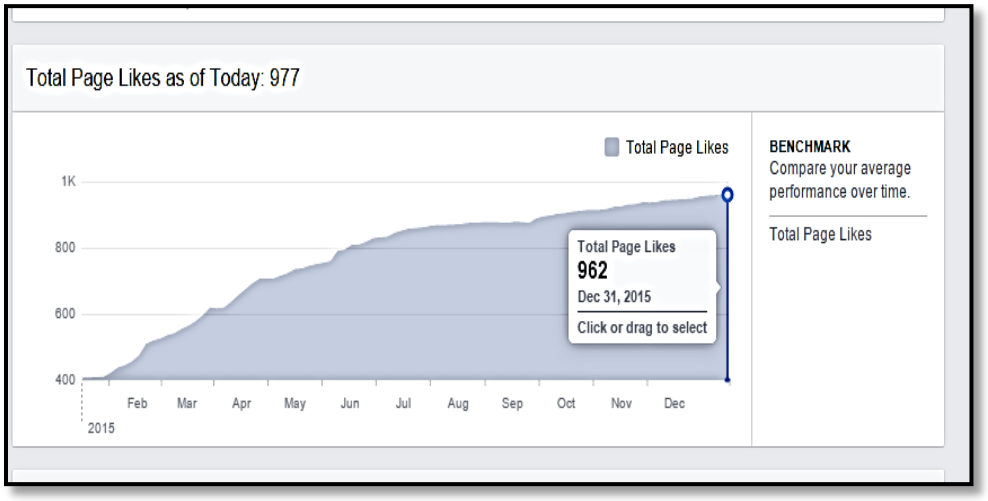


Figure : Social media reach statistics

8.3 Lessons Learned and Recommendations

The participation of the local community in mangrove restoration and protection initiatives is one of the most important factors in the success and long term sustainability of the program. Though there has been immense community participation on Leguan Island, one of the greatest challenges remains the commitment and participation of local communities. The department was challenged to motivate residents at other intervention sites to participate in mangrove protection and awareness and to become involved in the monitoring of their coastal resources. The will to change old habits and action of dumping and illegal grazing still remains of great concern.

It is anticipated that the results of the local government elections will provide an opportunity for renewed strategic alliances with NDCs to implement community projects and improve community participation and awareness.

There are limited sites with suitable characteristics to support and accelerated mangrove restoration through seedling planting program. 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 Spartina grass to promote sediment consolidation and coastal structures such as groynes to promote accretion will continue to play an important role in future restoration designs.

While the public awareness and education campaign has resulted in significant reduction on mangrove destruction, there continues to be conflict with regards to land tenure and the protection of mangroves on private lands. Mangrove destruction for the production of burnt bricks used in the road construction industry continues to be a problem, though apparently restricted to the Abary area. The laws protecting mangroves are vested in sister agencies and continue to prove challenging to enforce. While the department collaborates with these agencies and the Ministry of Public Works, now the Ministry of Public Infrastructure, has

signed an MoU with MoA and the Ministry of Natural Resources on coastal zone management, there is need for a more streamlined and interagency approach to mangrove restoration and management of the coastal zone.

The invasion of Sargassum along the coastline during 2015 raised a number of concerns and highlighted that not enough is known about the damage it causes or a sustainable solution to the problem.

While the department has been able to achieve a significant portion of its 2015 programe, the cost associated with monitoring and the ability to attract quality support staff continues to be a challenge.

9.0 HUMAN RESOURCES DEPARTMENT, 2015

1. **RECRUITMENT – Thirty (30) persons were recruited in 2015 as follows:**

A. **CROP DEVELOPMENT AND SUPPORT SERVICES**

Name	Designation	Date of Employment
1. Patricia Peters	Crop Ext. Assistant (Reg. # 9)	2015-04-01
2. Alicia Hendricks	Crop Ext. Assistant (Reg. # 4)	2015-09-01
*3. Celpha Simon	District Crop Ext. Off. (Reg. # 8)	2015-09-01
*4. Ameer Mohamed	Crop Extension Asst. (Reg. # 2)	2015-09-01
5. Neisha Vantrompe	Crop Ext. Asst. (Reg. # 6)	2015-09-16

B. **GENERAL ADMINISTRATION AND FINANCE**

Name	Designation	Date of Employment
1. Farzana Rahim	Data Entry Clerk (Mon Repos)	2015-02-09
2. Godfrey Bess	Internal Auditor (Mon Repos)	2015-08-03

C. **GENERAL SERVICES**

Name	Designation	Date of Employment
1. Jagdesh Ramrattan	General Worker (Mon Repos)	2015-01-06
2. Rex Samlall	General Worker (Reg. # 9)	2015-01-12
3. Theon Rodrigues	General Worker (Kairuni)	2015-01-22
4. Carlos Hall	General Worker (Kairuni)	2015-01-22
5. Fazal Deendial	General Worker (Mon Repos)	2015-02-02
6. Winston Martin	General Worker (Reg. # 9)	2015-02-04
7. Padmini Harpaul	General Worker (Mon Repos)	2015-03-02
8. Mohamed Fazil	General Worker (Mon Repos)	2015-03-03

9. Loaknauth	General Worker (Loaknauth)	2015-03-16
10. Colin Hercules	General Worker (Ebini)	2015-05-01
11. Jason Boyce	General Worker (Reg. # 2)	2015-05-01
12. Keon Benjamin	Gen. Wkr. (Build/Maint.) (Mon Repos)	2015-06-22
13. Alfanso Caripuna	Heavy Duty Operator (Reg. # 9)	2015-07-02
14. Imtiaz Rahaman	General Worker (Mon Repos)	2015-07-22
15. Tywane Livingstone	General Worker (Brush Cutter Opr. (Mon Repos)	2015-07-28
16. Ralph Flemming	General Worker (Ebini)	2015-10-01

D. **MANGROVE**

Name	**Designation**	**Date of Employment**
1. Rawle Medford	Ranger (Reg. # 6)	2015-11-02

E. **NATIONAL PLANT PROTECTION OFFICE**

Name	**Designation**	**Date of Employment**
1. Belinda Nandalall	Quarantine Inspector (Reg. # 2)	2015-09-28

F. **RESEARCH AND DEVELOPMENT**

Name	**Designation**	**Date of Employment**
1. Faron Pearson	Research Asst. (Mon Repos) Temp.	2015-08-17
*2. Elton Wray	Research Assistant. (Mon Repos)	2015-09-01
*3. Julian Nedd	Research Assistant (Mon Repos)	2015-09-01
*4. Vickash Nandanie	Research Assistant (Reg. # 5)	2015-09-01
5. Ray Imhoff	Res. Asst. (Head, Ebini Operations) (Ebini)	2015-11-03

2. **RESIGNATION – Seven (7) persons tendered their resignations as follows:**

A. **GENERAL ADMINISTRATION AND FINANCE**

Name	**Designation**	**Date of Resignation**
1. Selina John	Secretarial Asst. (Mon Repos)	2015-12-31
2. Farzana Rahim	Data Entry Clerk	2015-09-28

B. **GENERAL SERVICES**

Name	**Designation**	**Date of Resignation**
1) Jitendra Persaud	- General Worker (Mon Repos)	2015-05-06
2) Rajendra Surujpaul	General Worker (Mon Repos)	2015-05-18

C. **MANGROVE**

Name	**Designation**	**Date of Resignation**
1. Alex Pestano	Ranger (Reg. # 6)	2015-06-09

D. **RESEARCH AND DEVELOPMENT**

Name	**Designation**	**Date of Resignation**
1. Nigel Cumberbatch	Snr. Research Sci. (Mon Repos)	2015-11-01
1. Rajiv Singh	Research Assistant (Mon Repos)	2015-12-03

3. **VOLUNTARILY WITHDRAWAL OF SERVICE – Five (5) persons have withdrawn their services as follows:**

A. **GENERAL SERVICES**

Name	**Designation**	**Date of Withdrawal**
1**.** Fazal Deendial	General Worker (Mon Repos)	2015-02-21
2. Jagdesh Ramrattan	General Worker (Mon Repos)	2015-03-04
3. Mohamed Fazil	General Worker (Mon Repos)	2015-06-12

B. **NATIONAL PLANT PROTECTION OFFICE**

Name	**Designation**	**Date of Withdrawal**
1. Wazim Ramdin	Quarantine Insp. (Reg. # 9)	2015-04-20

C. **RESEARCH AND DEVELOPMENT**

Name	**Designation**	**Date of Withdrawal**
1. Paul Bhikram	Research Tech. (Reg. # 5)	2015-12-10

4. **NON RENEWAL OF CONTRACTS- Three (3) persons contracts were not renewed**

A. **GENERAL SERVICES**

Name	**Designation**	**Date of Withdrawal**
1. Charles Mitchell	General Worker (Ebini)	2015-04-30
2. Geary Leacock	General Worker (Ebini)	2015-04-30

B. **RESEARCH AND DEVELOPMENT**

Name	**Designation**	**Date of Withdrawal**
1. Samantha Pooran-DeSouza	Research Sci. (Mon Repos)	2015-04-30

5. **PROMOTION – Two (2) persons were promoted as follows:**

A. **GENERAL ADMINISTRATION AND FINANCE**

Name	Designation	Date of Promotion
1. Marcia Somerset	Accounts Clerk (Mon Repos)	2015-11-02

B. **RESEARCH AND DEVELOPMENT**

Name	Designation	Date of Withdrawal
Tracy Persaud	Research Sci. (Mon Repos)	2015-11-14

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

A. **GENERAL ADMINISTRATION AND FINANCE**

Name	Designation	Date of Death
1. Imdaad Sattaur	Internal Auditor (Mon Repos)	2015-02-27
2. John Martins	Accounts Clerk (Mon Repos)	2015-09-25

7. **TRANSFER – Two (2) persons were transferred as follows:**

A. **CROP DEVELOPMENT AND SUPPORT SERVICES**

Name	Designation	Date of Transfer
1. Beeshan Narine	District Crop Ext. Offr. (Reg. # 2)	2015-02-02
2. Chevy Bissessar	District Crop Ext. Offr. (Reg. # 9)	2015-02-01

8. **SPONSORSHIP STUDENT**

1. Miss Stacy Cassiano was sponsored by NAREI to attend the Guyana School of Agriculture for the academic years 2013-2015.

2. Ms Samantha Brotherson was sponsored by the Environmental Protection Agency to pursue an Online MSc Programme in Biosafety at the UWI effective August 31, 2015.

STAFFING AT NAREI

Categories	**No. of Positions**	**Positions Filled**	**Position Vacant**
Crop Extension Services	99	*84	16
General Admin. & Finance	82	49	33
General Services	157	120	37
National Plant Protection Office	52	*35	25
Research and Development	91	56	35
Mangrove	15	15	0
Total	**496**	**359**	**146**

*** Represents overlapping of one (1) Crop Extension Assistant, six (6) Plant Quarantine Officers and two (2) Plant Protection Officer which is reflected under staffing at CDSS and NPPO.**

NON CONTRACTED EMPLOYEES

Extension Agents	21

STAFFING IN THE CROP DEVELOPMENT AND SUPPORT SERVICES DEPARTMENT

Category	**Authorized Positions**	**Positions Filled**	**Vacant Post**
Deputy Chief Executive Officer	1	1	0
National Crop Extension & Training Coordinator	1	0	1
Training Manager	1	1	0
Regional Crop Extension Officer	12	9	3
District Crop Extension Officer	30	28	2
Training Officer	1	0	1
Senior Crop Extension Assistant	13	4	9
Crop Extension Assistant	40	41	0
Total	**99**	**84**	**16**

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

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	1	0
Human Resources & Admin. Manager	1	1	0
Finance Manager	1	0	1
Corporate Secretary	1	0	1
Internal Auditor	1	1	0
Projects/PRO	1	1	0
Senior Human Resources Officer	1	0	1
Librarian	1	0	1
Accountant	2	1	1
Human Resources Officer	2	2	0
Farm Manager	3	2	1
Administrative Assistant	2	2	0
Security Supervisor	1	1	0
Assistant Librarian	2	1	1
Storekeeper	4	2	2
Senior Human Resources Clerk	2	2	0

Confidential Secretary	2	2	0
Information Technology Technician	2	1	1
Senior Secretarial Assistant	1	1	0
Cashier	3	0	3
Accounts Clerk	6	6	0
Secretarial Assistant	6	2	4
Human Resources Clerk	2	0	2
Data Entry Clerk	1	1	0
Library Assistant	2	0	2
Security Guard	30	19	11
Total	**82**	**49**	**33**

STAFFING IN THE GENERAL SERVICES DEPARTMENT

Category	Authorized Positions	Positions Filled	Vacant Post
Heavy Duty Operator	10	6	4
Drivers/Office Assistants	20	6	14
Well Operator	1	1	0
Welder	1	0	1
General Workers	125	107	18
Total	**157**	**120**	**37**

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	7	0
Plant Quarantine Officer	5	*11	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	16	4
Total	**52**	**35**	**25**

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	7	8
Nurseries Manager	1	1	0
Research Assistant	30	30	0

Nursery Supervisor	5	1	4
Senior Research Technician	6	1	5
Research Technician	16	9	7
Laboratory Attendant	10	6	4
Total	**91**	**56**	**35**

STAFFING IN THE GUYANA MANGROVE MANAGEMENT DEPARTMENT

Category	**Authorized Positions**	**Positions Filled**	**Vacant Post**
Project Coordinator	1	1	0
Admin. Finance Officer	1	1	0
Monitoring Officer	1	1	0
Community Dev. Officer	1	1	0
Monitoring Officer/GIS Technician	1	1	0
Engineer	1	1	0
Ranger	9	9	0
Total	**15**	**15**	**0**

TRAINING

LOCAL

Workshop/Meeting/Training

1. Capacity Building Training on "Cassava Rapid Multiplication". May 18th – 20th, 2015. NAREI boardroom.

#	Name	Department	Dates of Attendance
1	Mr R. Ragnauth	Agronomy	May 18, 2015 (1 day only)
2	Ms Indira Persaud	Agronomy	May 18, 2015 (1 day only)
3	Ms Aretha Peters	Agronomy	May 18, 2015 (1 day only)
4	Mr Kumar Bishundial	Nursery	May 18, 2015 (1 day only)
5	Mr Ramesh Baichoo	Soil & Water Management	May 18, 2015 (1 day only)
6	Mr Aaron Ramroop	CDSS	May 18-19th, 2015 (2 days only)
7	Mr Quacy Smartt	CDSS	May 1 8th & 20th, 2015 (2 days only)
8	Mr Lawrence Louis	CDSS	May 18, 2015 (1 day only)
9	Mr Joel Greene	CDSS	May 18th & 19th, 2015 (2 days only)

2. Capacity building training on "the Reduction of Post-Harvest Losses along the Food Chain in Cassava and Pineapple'. September 14th – 18th, 2015, GLDA boardroom.

#	Name	Organisation
1	Mr Premdat Beecham	FVOC
2	Ms Mahadai Motielall	FVOC
3	Ms Indira Persaud	FVOC
4	Mr Rameshwer Raghunauth	FVOC
5	Ms Aretha Peters	FVOC
6	Ms Devika Singh	Soils
7	Mr Aaron Ramroop	CDSS
8	Mr Gavin Glen	CDSS
9	Mr Nehal Patterson	Region No. 3
10	Mr Talica Bristol	Region No. 3
11	Mr C. Lall	Region No. 4
12	Mr Joel Greene	Region No. 4
13	Patel Jairam	Region No. 5
14	Thanesia Joseph	Region No. 5
15	Mr Adele Pierre	NPPO
17	Mr Ariefa Hassan	Plant Pathology
18	Mr Aaron Hanif	Plant Pathology

19	Odania Chisholm	
20	Leon Folkard	NPPO

OVERSEAS

Workshops/Forums/Training Courses/Seminars/Meetings

1. Mr. Brian Sears, Assistant Chief Executive Officer attended the Tenth Session of the Commission on Phytosanitary Measures, Rome, Italy,16 to 20 March 201 in Rome, Italy.

2. Ms Samantha Brotherson, Research Assistant attended the Training Course "TRAINING COURSE ON DETECTION METHODS FOR GMO IN THE FOOD CHAIN" sponsored by the Regional Biosafety Framework Implementing Project in collaboration with the University of the West Indies, St Augustine Campus, during the period February 09-14, 2015 in Trinidad and Tobago.

3. Mr. Paul McWatt, Plant Protection Officer attended the training on 'Geographic System/Global Positioning System and the Fruit Fly Regional Data Interface' sponsored by the United States Department of Agriculture Animal and Plant Health Inspection Services (USDA-APHIS) in collaboration with the Ministry of Food Production, Trinidad and Tobago and the Ministry of Agriculture Barbados from 4th-5th and 8th-9th June, 2015 in Tobago.

4. Mr Evan Willabus, Research Assistant, attended the IICA-SAGARPA Training Programme on 'In-vitro Clonal Propagation of Tropical Plants' during the period 15/6/15 to 26/6/15 in Port of Spain, Trinidad & Tobago.

5. Mr. Roberto Mendez Pelegrin, Research Scientist attended the IICA-SAGARPA Training Programme on "Capacitation in: The biotechnology and its application in agriculture. Centro De Investigación Y Estudios Avanzados (CINVESTAV) Irapuato, Mexico" from June 22th to July 2th, 2015.

6. Mr. R. Nigel Cumberbatch, Senior Research Scientist attended the workshop to "finalise the position of NAREI and develop the detailed work plan of Guyana for the Agriculture Policy Programme which is funded by the EU" from June 22-24, 2015 in Trinidad and Tobago.

7. Mr. Royden Glen, Snr. Plant Quarantine Officer (ag), attended the Eighth Meeting of the Caribbean Plant Health Directors and Third Meeting of CARICOM Plant Health Directors from July 7-10, 2015 in Aruba.

8. Ms Kendra Belgrave, Plant Protection Officer attended the 4th Meeting of the Caribbean Plant Health Directors Emergency Response Preparedness Plans and Mechanisms for Response from September 17th -18th, 2015 in Anguilla.

9. Mr. Jonathan Wright, Plant Quarantine Officer attended the Regional Training Workshop on Pest and Disease Surveillance hosted by the United States Department of Agriculture Animal and Plant Health Inspection Services (USDA/APHIS) in collaboration with the Ministry of Agriculture, Forestry, Fisheries and The Environment from September 21st – 25th, 2015 in Grenada.

10. Mr Premdat Beecham, Research Assistant participated in the Regional Workshop on 'Promoting Cassava Farmer to Market Linkages through Contract Farming in the Caribbean" hosted by the Office of the Sub Regional Coordinator of the Food and Agriculture Organization of the United Nations (FAO) from October 19-23, 2015 in Barbados.

11. Mr David Fredericks, Research Scientist participated in a 2 day Caribbean Regional Climate Outlook Forum (CariCOF) sponsored by the Caribbean Institute of Meteorology and Hydrology (CIMH) in partnership with the World Meteorological Organization (WMO), the National Oceanographic and Atmospheric Administration (NOAA), the United States Agency for International Development (USAID),

Environment Canada, and the International Research Institute for Climate and Society (IRI) during the period November 26-27, 2015 in Basseterre, St. Kitts.

12. Dr. Oudho Homenauth, Chief Executive Officer attended a training workshop on 'Technologies for Agriculture Development and Market Diversification for the Cassava Crop' sponsored by CLAYUCA Cooperation and IICA during the period November 30 to December 4, 2015 in San Jose, Costa Rica

PUBLICATIONS

1. Abrahim, B. N., Clementson, C. & Homenauth, O. (2015) ***'An investigation of the potential impacts on air quality during operations of the Bioethanol Demonstration Plant in Albion, Berbice'***: Global Scholastic Research Journal of Multidisciplinary ISSN: 2349-9397: 1.13.

2. Cumberbatch, R. N., Homenauth, O., (et al) (2015) '***A Protocol for the Planting, Managing and Cost of Establishing a Fruit Orchard in the Intermediate Savannahs of Guyana'***: Global Scholastic Research Journal of Multidisciplinary ISSN: 2349-9397. Issue 12.

Appendices

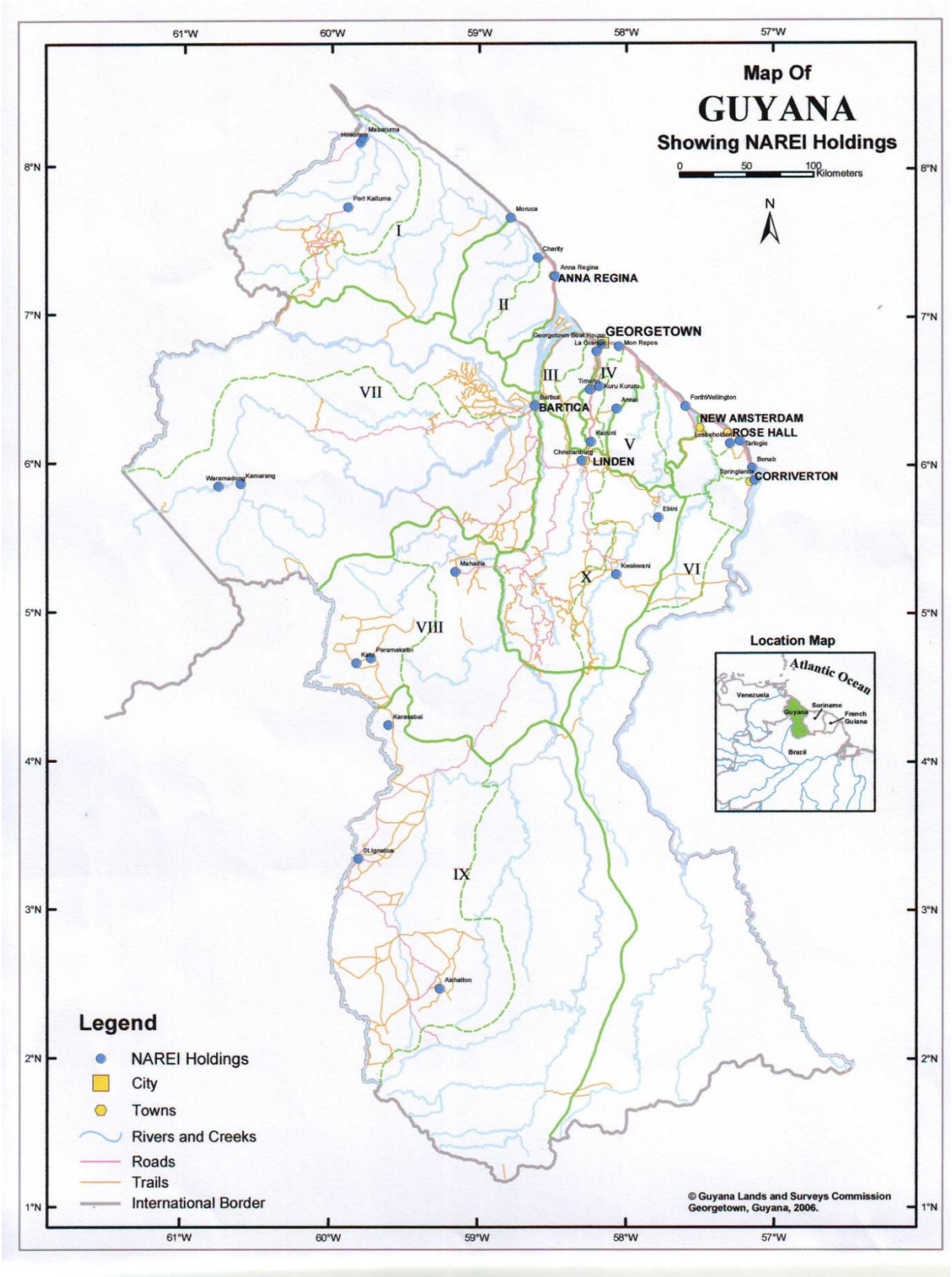
Appendix 1: Achievements for January - December 2015

No.	Activities	Achievements 2015
1.	**RESEARCH & DEVELOPMENT**	
	Development of fertilizer packages for two new sweet pepper varieties (Goliath & King Arthur) under open field and shaded condition.	Field activities completed and technical reports prepared. Agronomic packages available to farmers
	Cost of establishing a five acre orchard at Ebini	All data collected in the first phase. Publication done in the Global Scholastic Research Journal titled ' A Protocol for Planting, Managing and Cost for Establishing a Fruit Orchard in the Intermediate Savannahs of Guyana'.
	Evaluation of new carrot varieties under shaded conditions.	Plots established. Harvesting to be done in January 2016
	Evaluation of orange sweet potato sourced from Jamaica	A 1.5 acre plot has been established and is being monitored.
	Investigating the use of biostimulants and limestone to improve production/ productivity of cassava.	The trials established at Salem and Craig have been harvested. Reports finalized.
	Establishing a Digital Soil Database using GIS.	Draft Project Document for GIS phase of National Soil Inventory Completed.
	Effect of rice husk biochar as an amendment on a Marginal Soil (oxisols) in Guyana	Study completed. Report being prepared for publication.
	Observational trial on purple onion under shaded conditions	Initial trials completed. To be replicated on farmers holdings.
	Evaluation of the efficacy of five Rhizobia Inocula on Fijou in Field 17, Mon Repos	Trial in fruiting stage.
	Development of micropropagation techniques for multiplication and conservation of different crop plants (e.g. cassava, sweet potato, pineapple, plantain and bananas).	In pineapple, the multiplication rate achieved was in the proportion of 1:5 – 1:7 after the second subculture. In the hardening process 450 plantlets were transfer to pot with 72.8% survival (328 plantlets). In sweet potatoes the multiplication rate was the 1:4

		after the second subculture. In the hardening process an 88% survival was attain 250 plantlets were transfer to pots 220 survive. In other crops like cassava and plantains and banana multiplication rates of 1:3 and 1:5 respectively was obtained. Advances have been accomplished with the in vitro culturing of zygotic embryos excise from dry coconuts. A high level of germination (90%) was observe on all the accession. However, not all the embryos germinate uniformly and lack of plant development was observing in a great number of them. Better responses were observed in the hardening of coconut plantlets reaching 88.8% survival.
	Collection, micropropagation and storage of local accessions of plantains and bananas	With the idea of protecting our native plant genetic germplasm and having it readily available for use in a given time, the in vitro conservation techniques offer a secure tool in achieving this goal. In this regard, a local germplasm collection of some of the most important crop was initiated in 2015. Collecting 12 different accession of cassava, 8 accession for plantain and bananas, 5 accessions for Sweet potato, 3 accession for pineapple and 8 accessions of coconut palms not clearly identify (18-months, 3 years, 5 years and dwarf nuts green and yellow).
	Assessment of the potential water quality effects resulting from the release of vinasse, from the Bioethanol Demonstration Plant, into the surrounding waterway.	Data analysis and report completed.
	Expansion of soybean cultivation	Variety identified for commercial cultivation. Initial 22 acre plot evaluated by Investors. Discussions in progress on expansion of cultivation with private investor.
	Development of a roadmap for the coconut industry	Draft prepared and finalized by the National Stakeholders Forum
	Enhancing capacity to manage BSD disease	Field work completed and additional training provided to staff by CARDI.

	Continuous monitoring and provision of technical assistance for the management of the RPM.	Programme currently being intensified with the provision of chemicals and training to farmers
	Establishment of a high tunnel structure at Berbice Campus in collaboration with IICA to promote climate smart practices	Construction completed and planting in progress.
	Supporting the development of an agroprocessing industry in Guyana	Data collected for 2014 showed that 1,537 tons of processed foods were exported. Data collection for 2015 completed.
2.	***Mangrove Management and Restoration:***	
	Mangrove Restoration	8,038 shoots of Spartina grass planted along the ECD and Essequibo Coast. Maintenance of structures at Buxton and Victoria Completed. Brushwood Dam at Walton Hall completed.
	Monitoring/Research	Completion of monitoring and data collection in forest health and survival rates at six sites. Report being finalized.

Appendix 11: NAREI Holdings



Appendix 111: Crop Production Data for Selected Commodities

Commodity	TOTAL		
	2013	2014	2015
Legumes	**MT**	**MT**	**MT**
Corn	250	1,134.38	4,618.00
Minica # 4	1,178.00	1,138.00	788
Oil Seeds	-		
Coconuts (dry) - each	23,216.00	33,348.00	90,960.00
Provisions			
Cassava (sweet)	7,650.00	30,228.38	29,170.00
Sweet Potato	2,144.00	12,631.95	20,683.00
Eddo	3,385.00	17,331.89	9,780.00
Plantain	15,246.00	46,545.90	6,954.00
Other provision (Yam)	826	1219	2,721.00
Vegetables	-		
Tomato	11,657.00	14,984.95	21,480.00
Cabbage	2,255.00	7,428.53	12,378.00
Pumpkin	9,622.00	12,587.04	29,536.00
Bora	8,270.00	10,013.52	21,269.00
Ochro	3,394.00	36,615.11	17,768.00
Boulanger	5,741.00	20,900.11	37,709.00
Squash	3,172.00	3,855.01	6,455.00
Cucumber	3,144.00	9,249.82	4,816.00
Spices & Seasoning	-		
Eschallot	4,428.00	1,169.69	2,367.00
Hot Pepper	7,969.00	9,667.90	12,628.00
Ginger	1,915.00	5,917.10	17,779.00
Citrus	-		
Lime	986	6,293.63	1,962.00
Grapefruit	297	7,400.55	326
Orange	2,581.00	1,492.09	9710
Fruits	-		
Avocado (Pear)	211	5,773.24	6773
Mango	1,125.00	2,577.08	2,606.00
Banana	5,168.00	11,845,76	15,575.00

Pineapple	6,113.00	47,419.00	19,259.00
Watermelon	2,191.00	18,897.69	24,529.00
Cherry	1,249.00	2,008.81	3,150.00
Passion Fruit	889	1,469.73	1,973.00
Papaw	4,980.00	5,860.31	61,913.00
Coconut (water nuts)		9,356.00	10.34
Total	**141,252.00**	**384,514.41**	**497,645.34**

Appendix IV: Crop Production Data for 2015

	1st Quarter		2nd quarter		3rd Quarter		4th Quarter		2015	2014	Difference between
Crop(2015)	Acreage	Production	Acreage	Production	Acreage	Production	Acreage	Production	Total Annual Prod	Total Annual Prod	2014 and 2015
Banana	1223.569	3089.5	1229.2	3103.7	1850.5	4672.6	1863.2	4704.5	15570.4	11845.8	3724.6
Beans	283.865	198.7	72.6	50.8	384.8	269.3	385.8	270.1	788.9	1138.1	-349.2
Bitter cassava	1701.515	5402.3	1880.9	5971.9	1583.5	5027.5	1705.8	21663.7	38065.3	13214.4	24850.8
Bora	741.882	5044.8	844.5	5742.6	752.2	5115.1	789.2	5366.7	21269.2	10013.5	11255.7
Boulanger	568.951	9273.9	700.0	11410.0	517.7	8439.2	526.8	8586.8	37709.9	20900.1	16809.8
Bread Fruit	6.732	61.3	6.7	61.0	9.2	83.7	9.2	84.2	290.1	196.2	93.9
Breadnut	9.17	48.6	9.2	48.8	7.2	38.3	5.9	31.3	166.9	128.4	38.5
Broccoli	1.55	6.2	-	0.0	1.4	5.5	1.4	5.5	17.2	5.8	11.5
Butternut squash	1.76	25.9	4.2	61.7	0.5	7.5	0.5	7.5	102.6	66.3	36.3
Cabbages	197.6	2628.1	208.6	2774.4	215.0	1429.8	417.0	5545.7	12378.0	7428.5	4949.4
Callaloo	114.53	3103.8	84.2	2281.8	207.0	2804.4	214.9	5823.8	14013.9	7599.2	6414.7
Carambola	143.763	1200.4	143.8	2401.5	158.5	2647.6	158.6	2648.1	8897.5	522.9	8374.6
Carilla	347.99	3027.5	226.2	1967.9	222.4	1935.0	351.8	3060.4	9990.8	3979.2	6011.6
Carrot	0.56	1.9	0.6	2.0	0.8	2.6	0.8	2.6	9.0	0.0	9.0
Cashew (Malaka)	20.77	316.7	20.8	317.2	23.3	0.0	43.3	0.0	633.9	328.2	305.8
Cassava	1818.297	5773.1	1767.7	5612.4	2780.7	8828.6	2820.7	8955.7	29169.8	30228.4	-1058.5
Cauliflower	2.555	10.4	-	0.0	2.1	8.6	9.1	37.1	56.2	34.4	21.8
Celery	82.619	2214.2	54.2	1452.6	683.0	4575.9	93.3	2500.6	10743.2	9978.5	764.7
Cherry	175.059	770.3	175.1	770.4	151.7	667.6	214.2	942.6	3150.9	2008.8	1142.1
Cocoa	212.37	892.0	212.4	892.1	204.0	856.7	204.0	856.7	3497.5	0.0	3497.5
Coconut	12115.005	43159.7	12115.0	14386.6	14069.0	16706.9	14069.0	16706.9	90960.1	35348.0	55612.1
Water coconut (# nuts)		4186944.0		4897237.0		672586.0		586279.0	10343046.0	9355682.0	987364.0
Coffee	109.46	49.3	109.5	49.3	118.1	53.1	118.1		151.7	306.3	-154.6

Corn	293.815	1078.3	257.4	944.7	359.2	1318.1	348.0	1277.3	4618.4	1134.4	3484.0
Cucumber	185.832	1321.3	107.9	767.2	190.7	1355.8	193.0	1372.2	4816.4	9249.8	-4433.4
Dasheen	42.7	264.7	56.6	350.9	2.5	15.6	22.5	139.6	770.9	1115.0	-344.1
Eddoes	474.572	2942.3	434.6	2694.5	531.7	824.1	535.4	3319.7	9780.6	17331.9	-7551.3
Eshallot	76.68	742.3	43.1	417.2	62.6	605.9	62.2	602.5	2367.9	1169.7	1198.2
Ginger	203.945	5996.0	203.9	5994.7	98.6	2897.6	98.4	2891.7	17779.9	5917.1	11862.8
Golden Apple	16.207	21.4	16.2	21.4	25.8	34.0	25.8	34.1	110.9	171.3	-60.4
Goose berry	1.555	8.7	1.6	9.0	1.1	0.0	1.3	7.2	24.9	14.6	10.3
Granadilla	1.135	1.7	5.4	8.3	1.1	1.6	0.9	1.4	13.0	16.3	-3.3
Grape Fruit	205.157		205.2	184.7	78.2	70.4	78.2	70.4	325.5	7400.6	-7075.1
Guava	34.574	147.3	34.6	147.4	38.1	162.1	40.3	171.5	628.3	217.6	410.7
Lemon	160.56	289.0	168.9	304.0	107.4	193.3	107.4	193.3	979.7	1845.2	-865.5
Lettuce	39.201	380.2	68.2	661.5	41.5	403.0	41.9	406.8	1851.6	235.9	1615.7
Limes	692.951	502.4	693.0	502.4	606.5	439.7	714.4	518.0	1962.5	6293.6	-4331.2
Mamee Apple	9.89	16.8	9.9	16.8	8.6	14.7	8.6	14.7	63.0	173.6	-110.6
Mangoes	335.058		335.1	1440.9	261.5	0.0	271.2	1166.0	2606.9	2577.1	29.8
Married man	3.89	45.9	11.1	130.9	5.1	60.2	11.9	140.1	377.0	143.4	233.7
Musk Melon	23.372	175.3	18.4	138.0	35.0	131.2	73.3	549.7	994.2	1114.2	-120.0
Mustard	0.728	4.7	0.7	4.5	1.2	7.4	1.2	7.4	24.0	0.0	24.0
Ochro	532.672	5113.7	469.7	4509.1	543.4	2608.4	576.8	5537.7	17768.8	37615.1	-19846.3
Onion	0.51	1.7	0.5	1.7	2.8	9.4	2.8	9.4	22.1	0.0	22.1
Oranges	824.756		824.8		911.6	4831.3	920.7	4879.6	9710.9	4300.0	5410.9
Pakchoi	177.303	578.9	124.1	1620.7	151.1	1972.8	154.1	2012.1	6184.5	1492.1	4692.4
Papaw	836.482	25847.3	555.5	4291.2	180.8	1117.1	992.2	30657.8	61913.5	5860.3	56053.1
Parsley	4.365	100.0	4.4	100.8	4.0	91.4	4.0	91.6	383.7	122.5	261.2
Passionfruit	105.333	469.8	106.4	474.5	126.2	450.2	129.9	579.4	1973.9	1469.7	504.2
Peach	1.83	3.3	1.8	3.2	2.2	4.0	2.2	4.0	14.6	13.1	1.4
Peanuts	75.952	106.3	28.6	40.0	32.2	45.1	32.0	44.8	236.3	329.9	-93.7
Pears	443.826		443.8		424.7	45.7	825.6		45.7	5773.2	-5727.5
Peppers	540.419	3458.7	505.6	3235.8	607.2	1943.0	623.6	3991.2	12628.7	9667.9	2960.8

Pigeon Peas	13.553	16.3	13.6	16.3	20.2	24.3	20.5	24.6	81.5	140.6	-59.2
Pineapples	2272.712	4090.9	2272.7	4090.9	3030.4	5454.8	3123.9	5622.9	19259.5	47419.0	-28159.5
Plantain	6268.682	18962.8	6418.8	19416.9	5124.9	15502.8	5170.1	15639.5	69521.9	46545.9	22976.0
Pomegranate	0.545	3.8	0.5	3.5	0.7	5.2	0.7	5.2	17.8	56.3	-38.5
Psydium	66.19	516.3	66.2	516.4	63.2	492.9	62.2	485.1	2010.6	473.8	1536.8
Pumpkin	1103.319	9378.2	1264.6	10749.1	562.7	2391.5	825.5	7017.1	29535.9	12587.0	16948.8
Radish	0.07	0.3	0.1	0.4	0.0	0.0	0.0	0.0	0.7	0.0	0.7
Ramboutan	19.04	121.9	19.0	121.6	28.4	181.6	28.4	181.6	606.6	118.2	488.3
Saeme	100.616	812.5	100.6	812.3	113.4	915.8	113.5	916.1	3456.7	3554.1	-97.4
Sopadilla	75.3	158.1	75.3	158.1	29.3	61.6	29.6	62.2	440.1	492.3	-52.2
Sorrel	100.037	280.1	100.0	280.0	21.4	60.1	21.2	59.4	679.5	0.0	679.5
Sour sop	116.68	61.3	116.7	245.1	132.4	278.0	114.4	240.3	824.6	2013.8	-1189.1
Spinach	6.54	30.1	6.5	29.9	5.3	24.2	4.9	22.5	106.7	0.0	106.7
Squash	313.813	1820.1	237.1	1375.2	276.4	1603.2	285.7	1657.1	6455.5	3855.0	2600.5
Star apples	7.91		7.9		12.6	42.7	12.9	0.0	42.7	175.5	-132.8
Sugar apple	2.06	3.5	2.1	3.6	5.3	9.0	5.3	9.0	25.0	14.5	10.5
Sweet Peppers	376.722	7308.4	289.6	5618.2	128.4	2491.1	377.9	7331.0	22748.8	3503.0	19245.8
Sweet Potatoes	629.078	6102.1	631.5	6125.6	235.3	2282.8	636.4	6173.3	20683.7	12632.0	8051.8
Tangarine	352.387		352.4		436.0	1874.7	435.1	1870.8	3745.5	7461.1	-3715.6
Tannia	104.235	1261.2	104.2	1260.8	104.8	1268.5	104.9	1269.7	5060.3	4247.4	812.8
THYME	89.227	660.3	89.2	660.1	98.9	732.1	81.2	600.9	2653.4	4483.7	-1830.3
Tomatoes	440.55	7225.0	345.0	5658.0	343.7	2818.3	352.4	5778.8	21480.1	14984.9	6495.2
Turmeric	5.293	90.0	5.3	90.2	5.1	85.9	5.0	85.7	351.9	64.9	287.0
Water Melon	1114.758	9475.4	726.3	6173.6	519.9	4418.9	524.9	4461.5	24529.4	18897.7	5631.7
Yam	61.132	467.7	70.8	541.6	106.8	817.1	117.1	895.5	2721.8	1219.1	1502.7
Total	39865.291	204762.6	38918.4	152322.1	40790.3	129665.6	43356.0	208901.2	695651.4	462975.9	232675.5

From 15926 samples across 10 regions.

Appendix V: Summary VMAC Community Action Plans

VMAC	Key Issues	Proposed Activity	Outcome
Wellington Park	Animal grazing Garbage dumping Lack of knowledge on mangrove ecosystems Community development	House to house awareness Public awareness Capacity building session at VMAC meetings and mangrove heritage trail tour Installation of school sign at WP nursery school	Residents become more appreciative of mangrove forest, improve public awareness skills.
Village # 8	Lack of participation and miscommunication Use of mangrove center Garbage dumping Cutting of mangroves Animal grazing	Revisiting stakeholders Develop practical usage plan & enhancement to conduct school tours Public awareness drive and flyers distribution to sensitize residents	Encourage support for mangrove restoration so that there is broad based representation
Buxton	Erosion Lack of Knowledge on mangrove ecosystem Community development	Community awareness on the status of mangroves School presentation, house to house awareness & 1 day mangrove seminar for children Painting of 4 pedestrian crossings	Encourage support for mangrove restoration, updating residents about the status of mangroves & promoting VMAC
Greenfield	Lack of participation Lack of knowledge on mangrove ecosystem Community development	Extensive village awareness Capacity building at VMAC meeting Development of a school's environmental club	Awareness stimulate peoples interest in mangrove restoration club will help in the maintenance of mangrove forests
Mon-Repos	Lack of membership Lack of knowledge on mangrove forest Community development	Revisiting stakeholders Capacity building, house to house awareness Renovation of play park	Residents become more appreciative about mangrove forest and its benefits
Victoria	Lack of membership Education awareness Community development	Recruit new members Enhance mangrove heritage trail tour, school debate Sea wall enhancement	Preserve the aesthetic value of the area. Increase membership and awareness