

Session 1: Etiology and Epidemiology of Diseases

1. Ecology of emerging vector-borne plant viruses and their integrated management in tropical vegetable production system

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Vegetable crops are largely cultivated in tropical and sub-tropical regions of the world. In India, vegetable cultivation occupies an area of 6.2 million hectare with a production of 84 MT, accounting for 13% of world vegetable production. Plant virus diseases cause tremendous economic losses, particularly in the tropical conditions. Most plant viruses depend on vectors for their survival and spread. Virus transmission by a vector is often characterized by some degree of specificity. Numerous studies suggest the involvement of a virus-ligand interaction in transmission specificity. Most vectors of plant viruses are sucking insects such as aphids (Aphididae), whiteflies (Aleyrodidae), leaf hoppers (Cicadellidae), plant hoppers (Fulgoroidea), scale insects (Coccidae), mealybugs (Pseudococcidae), thrips (Order Thysanoptera) and mite pests (Acari), all are potential to cause serious threat to vegetable production due to direct feeding damage and vectoring plant viruses. These insect-vectors with their small syringe-like stylets introduce virus into plant cells or vascular tissues that transmit plant viruses in either the circulative virus (CV) or non-circulative virus (NCV). NCV are carried on the lining cuticle of vectors stylets, while the CVs cross the vectors' gut, move internally to the salivary glands (SG), cross the SG membranes to be ejected upon feeding. Transmissibility of NCVs depends on motifs of coat protein and for Potyviruses and Caulimoviruses also on helper proteins encoded by the virus. The NCV proteins were found to associate with vectors' cuticle proteins. Transmissibility of CVs depends on proteins comprising the virus capsid, the coat protein and the read-through protein, and on symbionin produced by vectors' symbionts. The passage of CV through the gut has been also associated with vectors' proteins. All these vector-borne plant viruses cause extensive losses in diverse vegetable production system throughout the tropics. The number of viral epidemics has dramatically increased in recent years, as have the threat of emerging new diseases and the reemergence of other diseases. Furthermore, crop plants cannot be cured once infected by a virus. Such enormous economic losses inflicted by plant disease vectors have spurred a worldwide in search for cost-effective management strategies. Integrated management practices involving different measure is required as no single technique is likely to be successful to suppress plant virus epidemics. Building technical knowledge among farmers is vital to address these issues for successful management of vectors transmitting crop diseases. This paper focuses on the research efforts made on ecology of virus-vector interactions, and the experience from the fields in implementing integrated practices such as cultural, host tolerance and resistance, environmental, biological and chemical control are discussed for effective management of vector-borne plant viral diseases in vegetable production system.

2. Healthy seed material – a myth or possibility.

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Pathogens are often carried through seeds and seed materials which constitute primary spread of the diseases. Though it appears to be insignificant when compared to the amount of pathogen inoculum load available in the soil or growth medium, in real sense it contributes to the very starting point of various infections and infestations. There are several bacteria, fungi and viruses that are seed borne or carried through the seed materials, inside, outside and at both surfaces. Careful inspection of source plants for seed extraction and simple methods of monitoring and treatment can vertically reduce the spread of pathogens through seed material. In Trinidad the common practise is to buy seed material from open market from external sources. Even with reputed sources, often there is less guarantee for seeds to be free from pathogens though there are supposed to be healthy. Preventative treatment methods including chemical and biological methods and farmer's-based community seedling production methods can warrant use of disease free seed material. This paper discusses about the various strategies which could be adopted farmer's level towards production and use of disease free seed material for planting.

2. Common Pre- and Post-harvest Diseases of Vegetable crops in Jamaica

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Vegetables production in Jamaica, as in around the world, faces many diseases that affect the yield and the quality of the fresh harvest produce. However, many diseases are more predominant than others. The most observed diseases of vegetables are anthracnose, leaf spot, club root, downy mildew, grey mould, mosaic virus, early blight, septoria leaf spot and leaf rusts. However other diseases can be found and could affect seriously vegetable crops. In Jamaica, greenhouse cropping systems are also affected by similar and other diseases such as septoria leaf spot, early blight, anthracnose, fusarium wilt, verticillium wilt, late blight, bacterial spot, bacterial speck, bacterial canker, grey mould, leaf mould, powdery mildew and elephant's foot disease. Although not specific to the country, many diseases are found more frequently than others, and the frequency varies with the region and the cropping system (in-door or outdoor).

4. Major Diseases Affecting Christophene Production in Trinidad

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A survey was carried out to acquire the latest information about the constraints involved in the cultivation of Christophene (Chayote: *Sechium edule*) in Trinidad. It was conducted in January and February months of 2016 with 24 farmers from different regions in the Northern Range, covering 74 acres of land. The survey results indicated that the fungal diseases pose serious constraints to the successful production of Christophene in the farmers' holdings. The infected leaf, stem and fruits samples from 10 random farms inclusive of main clusters was collected and diagnosed in the lab. Laboratory analysis of the samples showed that all the samples infected with *Didymella* spp. [Anamorph: *Phoma cucurbitacearum*] which is reported to cause gummy stem blight disease in most of the cruciferous vegetables. The samples exhibited shot hole, stem blight and black rot symptoms in leaf, stem and fruit respectively. The lesions were either circular or elongated possessing minute dark colour structures. The dark structures were confirmed as pycnidia in the microscopic analysis. The cylindrical hyaline conidia were observed from infected samples and isolated pure cultures during microscopic analysis. Out of 10 samples examined, 7 samples exhibited downy mildew infection and 2 samples showed *Cercospora* infection. In addition, the analysis of root samples showed the nematode infection. Overall, the analysis of infected samples revealed the major occurrence of gummy stem blight infection in all stages of Christophene production in Trinidad.

5. Disease status of pumpkins in the southern Caribbean.

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Pumpkins are a member of the Cucurbitaceae family, which also includes squash, cantaloupes, cucumbers, watermelons, and gourds. Pumpkin production in the southern Caribbean is considered relatively high compared to other crops grown in the region. This is due to the ease of cultivation, resistance to diseases and high yield (13,000-22,500 kg/ha). The market for pumpkin is high as it is not only consumed directly but is also a major constituent in many downstream food and beverage products. Pumpkin cultivation especially in tropical climates are plagued by many bacterial, fungal and viral infections. Pumpkin disease identification is of primary importance when treating pumpkin diseases. Diseases afflicting pumpkins are mainly foliar in nature or diseases of the fruit. A three year survey and monitoring program of pumpkin diseases was carried out throughout fields in Trinidad, Guyana and St. Vincent. During these visits, disease incidence, aetiology and farmer management practises were recorded. The results of these would be presented.

6. Sexual Reproduction & Pre-harvest challenges in the cultivation of *Pimenta dioca* L. (Merr.) in Jamaica.

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A member of the species-rich, fleshy-fruited neotropical Myrtoideae, *Pimenta dioica* is an important spice-producing tree found abundantly all over the island of Jamaica. The plant is cryptically dioecious in sexual function producing the berries used to make allspice, only on 'female' trees. Allspice arboriculture faces a number of biotic and abiotic pre-harvest challenges, not least of which is its susceptibility to the rust fungus *Puccinia pisidii* which forms its orange-coloured urediospores on both the vegetative and reproductive portions of the plant.

7. Gummy Stem Blight- an emerging epiphytotic of cucurbits

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Gummy Stem Blight is an up-and-coming plant disease that is generally known to target cucurbits, also known as the *Cucurbitaceae* or gourd family. This family includes crops such as cucumbers, cantaloupes, watermelons, squash and that of pumpkins. This disease is said to be caused by a fungus known as *Didymella bryionae* and can occur during any development stage of the host crop whereby symptoms can take place at the foliar, stem and fruit level. Factors that aid in the facilitation of Gummy Stem Blight within cucurbits comprise temperature, wounds to the plant either due to feeding insects or prior diseases and most importantly, the presence of moisture. Plant samples were collected based on visual symptoms from pumpkin fields throughout Trinidad. Isolations of pathogens and PCR confirmation was done with species specific primers. Pathogen was confirmed to be *Stagonosporopsis cucurbitacearum* (anamorph of *Didymella bryionae*) based on the sequencing results. Suitable farming practices and or preventative measures can be done to lessen the risk of infection. Some of these include the buying and planting of disease-free seeds, crop rotation, the use of fungicides, proper irrigation, removal of any already diseased material and the possible use of phytoelicitors

8. Disease status of field Tomatoes in the southern Caribbean

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Tomato (*Solanum lycopersicum*) is one of the major crops cultivated in the southern Caribbean region. Production in these countries is mainly geared toward supplying local markets but a significant portion is exported mainly to other Caribbean islands. A tropical climate allows for the year-round cultivation of this crop in open field systems and farming is intensive with little to no fallow period. It is not uncommon to find a number of diseases associated with tomato during growth seasons that reduce yield and affect fruit quality. Tomato diseases can be grouped into symptom categories that assist with identification and proper control of the causative agent. Once identified, with an understanding of the disease agent and its ability to cause damage and spread, the proper control can be initiated. These include the wilts, leaf spots/blights, fruit spots and rots and viruses. A three year survey and monitoring program of tomato diseases was carried out

throughout fields in Trinidad, Guyana and St. Vincent. During these visits, disease incidence, aetiology and farmer management practises were recorded. The results of these would be presented.

Session 2: Pathogen variability and Plant Disease Diagnosis

9. Rapid molecular methods for plant disease diagnosis (Lead Paper).

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Proper diagnosis is an important component in the management of plant diseases. Traditional microscopic and culture based techniques generally require a long time for completion, are often subjective and cannot resolve identity of pathogens at low levels of taxa. Methods based on serology and analysis of fatty acids and carbon utilization profiles are also available but are not always suited for tropical isolates because of strain variations and their limited representations in diagnostic databases. The advent of revolutionary polymerase chain reaction and nucleic acid sequencing based methods now make it possible for accurate and rapid detection and identification of plant pathogenic agents, even without the need of a culturing step. The paper discusses the development and application of these molecular methods for plant disease diagnosis and their relevance to integrated disease management. The use of single-plex and multi-plex PCR, RT-PCR and real-time PCR are highlighted together with Sanger and next-generation sequencing in identifying pathogens at different taxonomic levels as well as detecting strains possessing agronomically important traits. Emerging technologies such as deep sequencing of sRNA for detecting unique viruses infecting plants and MALDI-TOF Mass spectrometry identification systems are also discussed.

10. Population shifts in bacterial spot causing *Xanthomonas* Florida tomato (Lead Paper)

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Tomato is a widely cultivated fruit crop in United States. Florida is the largest producer of fresh-market tomato in the US. Bacterial spot is consistently an economic threat for tomato growers in Florida. Disease management is challenged by shifts in bacterial populations over time and resistance development against commonly used bactericides. In recent years, only *X. perforans* strains has been found in Florida. Several tomato genotypes have gene-for-gene resistance against *Xanthomonas*. Since 1991, the Florida *X. perforans* population has shifted from tomato race 3 (T3) to 4 (T4) such that the effector protein AvrXv3, specific to T3, is non-functional in T4 strains and is not recognized by the corresponding tomato R gene. Previously, only tomato race 1 (T1), *X. euvesicatoria*, was isolated from bacterial spot affected tomato in Florida. In 1991, T3 *X. perforans* was identified that produced antagonistic bacteriocins against T1 *X. euvesicatoria*. Later in 1998, the first T4 *X. perforans* strain was identified. A survey conducted in 2006 reported that approximately 70% T4 and 30% T3 *X. perforans* strain were present in Florida. In a 2012 survey, T4 strains completely replaced the T3 strains. Recently, *X. perforans* pathogenic to pepper has also been identified. As part of this population shift in *X. perforans*, recombination events have been reported between *X. perforans* and *X. euvesicatoria* species. Sequence analysis of representative strains collected since the initial identification of *X. perforans* showed notable changes in effector profiles that are specific to phylogenetic groups. Interestingly, effectors XopJ4 and AvrBs2 are conserved throughout these population changes and AvrBsT has been established in the recent bacterial population. These conserved effectors can be used as potential targets for resistance breeding efforts in tomato.

11. Newly identified potyviruses causing severe mosaic in cucurbits

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The first report of newly emerging potyviruses such as Zucchini yellow mosaic virus (ZYMV) and Squash mosaic virus (SqMV) causing severe mosaic in cucurbits in Trinidad was recently reported in plant disease journal by our research group. Further studies were carried out for the molecular characterization of full length genome of Zucchini yellow mosaic virus. For that ten different sets of overlapping primers targeting the entire genome of ZYMV were newly designed in this study based on the publically available genomic information in NCBI genbank. The leaf samples from 10 severely mosaic affected pumpkin plants were collected from different farmers' fields throughout Trinidad located at Barrackpore, Macoya, Las Lomas, Moruga, Waterloo and Orange Groove and total RNA was isolated from all the samples. RNA (1 µg) was used for cDNA synthesis and PCR was performed with ZYMVCP-F1/ZYMVCP-R1 targeting coat protein of ZYMV to confirm the infection. After confirmation PCR was performed with ten different sets of overlapping primers to obtain full length genome of ZYMV. All the PCR amplicons were gel purified, cloned in pGEM®-T vector and sequenced by Sanger sequencing method. The overlapping sequences obtained in sequencing results in all the amplicons were trimmed with BioEdit tool and the complete genome (~9590 bp) of the ZYMV was retrieved from the Trinidad samples. Further phylogenetic analysis was carried out with 47 ZYMV complete genome isolates reported from 17 different countries was retrieved from Genbank and phylogram was constructed by Mega 6.06 software with 1000 bootstrap replications. In

phylogram Trinidad isolates of ZYMV were placed in a separate cluster and it is shared close relation with NAT isolate (EF062582) from Israel with 94.1 % nucleotide identities followed by 94.0 % identities with SEO4T (Slovakia), AG (Israel) and H (Czech republic) isolates. The lowest nucleotide identities of 80.6 % was obtained with ZYMV13PREP from Reunion Island. The results from the phylogenetic analysis revealed the new strain of ZYMV isolate from Trinidad since it is found with more than 6.0 % nucleotide variability with rest of other ZYMV isolates from other countries.

12. Quantification of disease severity in field and laboratory grown cassava by application of molecular markers for measuring Super-elongation disease.

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The fungal pathogen *S. manihotica* produces large amounts of gibberellin GA4 in late stages of Super elongation disease (SED), due to the expression of the Smp450-2 gene in infected cassava plants. Laboratory grown cassava plants were inoculated with a suspension of *S. manihotica*; DNA was extracted over a 21 day period and then amplified via PCR using SPM primers designed from the Smp450-2 gene. In laboratory grown cassava, late stage SED was not observed although this was evident in field grown cassava. However SPM primers were able to amplify the same 600bp fragment in DNA extracted from both laboratory grown cassava and field cultivated cassava plants; although late stages of SED were not observed in planta. In addition, field grown cassava displaying differential SED symptoms such as cankers on stems and necrotic leaf lesion produced variations in band intensities when DNA from these tissues were amplified with SPM primers. This may indicate the ability of this method to measure disease severity in cassava showing symptom of SED. Quantification of disease severity in cassava by use of molecular markers is important in management of local planting material and in continuous assessment of SED tolerant varieties of cassava which are widely distributed in the Caribbean region.

13. Morphological, pathological and molecular variability of *Alternaria alternata* causing leaf blight of onion in the southern region of India

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Leaf blight disease is one of the major economic constraints to Onion production in tropical and subtropical regions. The infected samples were collected from farmer's fields in different onion growing areas of Tamil Nadu, India and fungal pathogens were isolated from the infected leaf. The isolates were identified as *Alternaria alternata*, based on morphological cultural by Indian Type Culture Collection, New Delhi (ITCC No.5574) and molecular character also. The isolates

were evaluated for their morphological and cultural characteristics, pathogenic variability on onion plants. The pathogenic virulence of all the fungal isolates was determined glass house by artificial inoculation on leaves at glass house condition. The measurement of disease severity of onion revealed differences in the virulence between isolates. The molecular variability among isolates of *A. alternata* that differed in virulence was analysed by means of random amplified polymorphic DNA (RAPD) by using 10 random primers. Analysis of the genetic coefficient matrix derived from the scores of RAPD profile showed that minimum and maximum per cent similarities among the *A. alternata* were in the range of 22.85 to 85.71% respectively.

14. Molecular characterization of *Tomato yellow leaf curl virus* infecting Tomatoes in Trinidad

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Over the past two years from 2014 we have noticed severe symptoms such as stunting, upward curling of leaves and reduction of leaf size in tomatoes in different farmer's field throughout Trinidad. These symptoms were suspected to be indicative of the infection of Tomato yellow leaf curl virus (TYLCV). The leaf samples from 100 symptomatic plants were collected from different farmers' fields located at Maloney, Valencia, Tabaquite, Tortuga and Gasparillo in Trinidad. DNA was isolated from all the samples and PCR was carried out with begomovirus specific primers such as PAL1v1978/PAR1c496 and PTYCPv369/PTYCPC1023 targeting a partial region of DNA-A and PBL1v2040/PCRC1 targeting a partial region of DNA-B. Strong amplification was observed in 85 % of the samples using a TYLCV specific PCR with PTYCPv369/PTYCPC1023 primers targeting a partial coat protein (~654bp) region. Ten TYLCV specific PCR amplicons were cloned in pGEM®-T vector and sequenced. Blast analysis of all the nucleotide sequences shared 99.0 to 99.2 % identity with the partial V1 gene of a TYLCV-Israel isolate (FM163455). Further, full length viral genomes of Trinidad isolates from ten positive samples were amplified with MA13/MA26 primers targeting 1292bp and MA17/MA27 primers targeting 1835bp of circular DNA-A of TYLCV (Boukhatem et al. 2008). All the amplicons were sequenced and the complete genome (~2752bp) of the Trinidad isolates was obtained. All the sequences of Trinidad isolates were submitted to GenBank under accession numbers KU981040 to KU981049 and K224405 to KT224410. The phylogenetic relationship of Trinidad isolates were compared with 47 complete genome isolates reported from 22 countries and a Neighbor-Joining tree was constructed with 1000 bootstrap replications using MEGA 6.06 software (Supplementary Figure 2). Trinidad isolates showed 98.6 to 98.7 % nucleotide identity with isolate Grenada:Paradise (FR851298) from Grenada. TYLCV has not been reported previously in Trinidad and this study (under ACP-EU project), confirms presence of TYLCV and suggests the spread of this virus in Trinidad tomatoes via imported seed and by whiteflies from Grenada since both countries are in close proximity.

15. Angular leaf spot on *Cucumis sativus* (L) caused by *Pseudomonas syringae* pv. *lachrymans* in Barbados: molecular diagnosis and disease management.

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Plant disease diagnosis in Barbados is based mainly on biochemical and microbiological cultural techniques. The main objective of this study was to use molecular diagnostic techniques as an alternative to these traditional approaches. Repetitive extragenic palindromic polymerase chain reaction (REP-PCR) is a molecular diagnostic technique which can provide a fingerprint profile for Entrobacteriaceae. In this study, REP-PCR was used for molecular confirmation of suspected *Pseudomonas* spp. infecting *Cucumis sativus* (L.) (Cucumber) in Barbados. *Pseudomonas syringae* pv. *lachrymans* reference strains were compared to isolates from field and commercial varieties of cucumber. *Pseudomonas syringe* pv. *lachrymans* was detected in both seed and leaf tissue from an infected field and commercial seed samples of cucumber in Barbados. Leaf and seed isolates had similar molecular profiles to selected reference strains of *P. syringae* pv. *lachrymans* and displayed different REP-PCR profiles when compared to each other. Isolates from seed also showed more variation than leaf samples. This represents the first scientific report of the pathogen on the island and the data suggest that the presence of *P. syringae* pv. *lachrymans* in Barbados may be due to external and /or internal contamination events, through the use of imported seeds or spread by endemic epiphytes, respectively. A disease management strategy involving the use of tolerant cucumber varieties to angular leaf spot is proposed. Therefore, molecular diagnosis was used to improve the accuracy of traditional culture procedures and further assist with the development of a disease management strategy for cucumber cultivation in Barbados.

16. Identification and molecular diagnosis of viruses infecting pepper plants in Trinidad

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Pepper (*Capsicum annuum* L.) is an economically important vegetable crop in Trinidad. The harvesting of pepper is 27,000 pounds per acre. While consumption of pepper is increasing, the viral diseases cause a significant yield loss and commercial value of pepper every year. Various viruses are known to infect pepper worldwide, such as cucumovirus, begomovirus, fabavirus, potyvirus, tobamovirus, and tospovirus and often cause epidemics in pepper fields. However no clear reports are available in Trinidad with virus diseases in pepper plants. So this study is planned for the molecular diagnosis of viruses infecting pepper plants in Trinidad. The leaf samples are collected from pepper plants including hot pepper, bell pepper, pimento pepper, scorpion pepper, scotch bonnet pepper, congo pepper etc., noticed with mosaic, severe mosaic, leaf curling, yellowing symptoms throughout Trinidad. Nucleic acids are isolated from all the samples. The virus specific primers targeting the coat protein of the viruses were newly designed and will be used in PCR for the molecular identification. All the PCR amplicons will be gel purified, cloned in pGEM®-T vector and send it for sequencing. Using online bioinformatics

tools such as Blast and Clustal X the closest match of the virus will be identified and will be submitted in Genbank.

17. Molecular detection of pathogens of field tomato, cowpea and pumpkin.

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Tomato, cowpea and pumpkin are the important vegetable crops in Trinidad and Tobago. Fungi, bacteria and viruses are severely affecting these crops and causing serious diseases such as blight, damping off, root/stem rot, wilt, anthracnose, leaf spot and mosaic. This work is planned to identify these pathogens based on PCR based diagnostic techniques. The pathogens such as *Pythium*, *Colletotrichum*, *Macrophomina*, *Sclerotium*, *Microspora* and *Uromyces* were isolated from root, stem and leaf samples from diseased cow pea, tomato and pumpkin plants. Total RNA and DNA were extracted from plant samples and fungal mycelial mat from all the isolated pathogen. PCR was carried out with ITS forward and ITS reverse primer and also with species specific primers to amplify the corresponding fungi. The virus specific primers were used to amplify the viruses causing mosaic diseases in plants. The ITS primers efficiently amplified the *Pythium*, *Microspora*, *Sclerotium* and *Didymella* in PCR. Similarly species specific primers were also optimized to amplify the *Colletotrichum*, *Microspora*, *Uromyces* and *Sclerotium*. Coat protein specific primers were used to amplify the begomovirus, comovirus, potyvirus and cucumoviruses. Sequencing results of most of the PCR amplicons also confirmed the species identity of the pathogen.

18. Characterization of copper resistance and genetic diversity of *copA* genes in environmental bacteria exposed to copper pesticides at agricultural sites in Trinidad.

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Copper has been used as a fungicide and bactericide for decades in agriculture, quite often at higher concentrations than recommended. This creates an environment that selects for copper resistant bacteria. Copper resistant phytopathogenic bacteria have discovered since the 1970's and the genetic determinants (*cop* genes) shown to be plasmid borne. This has allowed for the rapid spread of *cop* genes among environmental bacteria present at agricultural sites. In Trinidad there is heavy use of copper based agrochemicals and a noticeable decrease in effectiveness with bacterial disease management. The tropics provide unique environments, this coupled with heavy copper can ensure that *cop* genetic diversity is high. Screens of 77 bacterial isolates using copper sulphate pentahydrate amended MGY agar showed that 71.4% of the isolates were copper resistant. Molecular screens with degenerate Coprun primers for the *copA* gene (highly

conserved among copper resistant bacteria) has shown that 27.3 % of these isolates contain a *copA* gene. The remaining 44.1% must contain *copA* genes that are genetically distant to the known *copA* genes covered by the Coprun primers. This was also found *Xanthomonas campestris* pv. *campestris* isolates from Trinidad, in a previous study, where a novel *copA* variant not picked up by Coprun primers was found. Further Molecular screens using primers designed for the *copA* variant mentioned showed that 37.7% of the 77 isolated contained that gene. Searching for these variant *copA* genes in the local environment is ongoing and essential to elucidate the genetic diversity of copper resistance in Trinidad due to anthropogenic sources.

Session 3: Integrated Disease Management

19. Control of fungal disease of tomato (*Lycopersicon esculentum*) fruits using vermiwash produced from medicinal plants in Guyana

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The demand for products and technologies based on plants to control plant pathogens has increased in recent years due to the concern about the use of hazardous pesticides. Plant growth parameters and effect of vermiwash from different against tomato fruit fungus (*Alternaria alternata*) were monitored during the study. The results from this study generally indicated that vermiwash with combination of neem+ earthworm+ cattle dung such as T3, T6 and T7 are very effective depending on their concentration or percentage to get rid of pathogens and improve yield and growth parameters of tomato fruit. The findings from this experiment generally indicated that vermiwash with combination of neem + earthworm + cattle dung such as T3, T6 and T7 are very effective depending on their concentration or percentage to get rid of pathogens and improve yield and growth parameters of tomato fruit. The treatment T1, T2, T6, T7, T8 and T9 at 10% dilution of vermiwash were effective against *A. alternata* affecting tomato fruits. At 5% there was no inhibition of *A. alternata*, T7 had a maximum of 12 colonies and T1 on the other hand a maximum of 5 colonies. At 10% growth of *A. alternata* were killed for most treatments except T3, T4 which consisted of two colonies each and T5 a colony count of 6. At 15% there was growth of *A. alternata* in all treatments except T8. Maximum growth was observed on petri plates containing T1 and T2 with a count of 8 colonies and a minimum growth of one colony present in T7. At 20% growth of *A. alternata* was observed in all treatments. The maximum growth was seen in T1 with 27 colonies and minimum growth in T5 with 1 colony. This indicated that at a concentration of 10% vermiwash would more likely to inhibit growth or kill the *A. alternata*.

20. Candidate genes in the selection of elite PGPR for the management of vegetable diseases

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Plant growth promoting rhizobacteria (PGPR) has multiple modes of action to benefit plant health. It promotes plant growth by producing various phytohormones such as auxins and cytokinins and an enzyme, 1-Aminocyclopropane-1-carboxylic acid deaminase (ACCD) which mediates high accumulation of stress ethylene. Further, it is studied as potential biocontrol agent in the perspective of reducing pathogen infection in plants. It directly inhibits deleterious microorganisms by production of an array of antibiotics [2,4 DAPG, Phenazine, Iturin, surfactin, fengycin, bacillomycin] and lytic enzymes [chitinase, β -1,3-glucanase] and indirectly reduces the disease development by inducing defense molecules in plants. Thus it is conceived that the knowledge of genes responsible for plant growth and biocontrol activity could be a boon to select the elite PGPR strain. This is further accomplished by the advent of molecular biology techniques. Therefore, the utility of candidate genes in selection of PGPR strains for the management of crop diseases with special emphasis on vegetable crops will be discussed in this presentation.

21. Current status of exploiting fungal entomopathogens in arthropod vector management in vegetable production system in India

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India is second largest vegetable producer next to China with a production of 84 MT and contributing 13% of the world produce. A variety of fresh market vegetables, including brinjal, chilli, tomato, bhendi, cucurbits, and crucifers are economically important crops in India. Majority of the commercially grown vegetable varieties are susceptible to many devastating diseases including a wide range of viruses, many of which are transmitted by arthropod-pests. Most vectors of plant viruses are sucking insects in the order Hemiptera. Aphids (Aphididae) transmit the greatest variety of plant viruses. Next in importance are the whiteflies (Aleyrodidae), followed by the leafhoppers (Cicadellidae), planthoppers (Fulgoroidea) and mealybugs (Pseudococcidae). A few plant viruses are transmitted by thrips (Order Thysanoptera) and mites (Acari), but their economic impact is internationally important. Incidences of vector-transmitted viral diseases in vegetable crops are on the increase in countries with tropical conditions. Many of the plant viruses not only inflict severe yield losses, but also substantially lessen the quality of crop products. The extensive use of conventional insecticides towards vector management has resulted in several ill-effects particularly, the development of severe pest resistance to insecticides, out-break of secondary pests, objectionable pesticide residues, direct hazard to the users and adverse effect on environment and non-target organisms. Development of effective methods of vector control can offer longer-term solutions. In this context, significant progress has been made over the last two decades on the interaction between viruses and their vectors through biological, biochemical, and molecular studies. Since majority of sucking insects and mites to have developed resistance to commonly used insecticides, biological control using fungal entomopathogens like *Beauveria bassiana*, *Metarhizium anisopliae* and *Verticillium*

lecanii has been explored for management of these vectors. Since the fungi are capable of infect their host by simple contact action, arthropod vectors with sucking habit are also targeted for mycoses. Even though fungal entomopathogens have been researched for more than 100 years, their effective use in the fields remains elusive. Recently, however, it has been discovered that many strains of entomopathogenic fungi play additional roles as endophytes, antagonists of plant pathogens, associates with the rhizosphere, and possibly even serves as plant growth promoting factors in nature. Furthermore, co-application of certain promising strains of fungal entomopathogens with suitable sub-lethal concentration of selective insecticide as two-in-one tank mix method have been successfully employed against some insect vectors to reduce the selection pressure of insecticides and to avoid concurrent risks of resistance. This paper updates about the recent progress in exploiting fungal entomopathogens in vector control and proposes future research strategies focused on alternate uses of candidate fungal entomopathogens for management of vectors for sustainable vegetable production system.

22. Phytoelicitor activity of certain local Caribbean seaweed species on suppression of tomato diseases

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Seaweed extracts are commonly used as phytoelicitors to promote crop growth and yield, worldwide. However, extracts of some species are known to induce defence processes in plant and may have potential for use as suppressive agents in the management of crop diseases. Most of the research on seaweed extracts as elicitors of plant defences were on temperate seaweed species. Caribbean islands have an abundance of tropical seaweed species along their coasts but their potential for use in agriculture has not been explored yet. The aim of this study was to determine the phytoelicitor potential of extracts of three seaweeds abundantly found in Trinidad and the southern Caribbean. The efficacy of the seaweed extracts in suppressing *Alternaria solani* and *Xanthomonas campestris* pv *vesicatoria* infections in tomato was analysed. Alkaline extracts of *Ulva lactuca*, *Sargassum filipendula* and *Gelidium serrulatum* were applied to tomato plants which were inoculated with the pathogens. The plants were then monitored over time for development of disease, activity of defence enzymes and expression levels of key marker genes of various plant defence pathways. Plants treated with the seaweed extracts showed reduced disease severity which was coupled with elevated rates of activities of defence enzymes. Seaweed extract treated plants also had increased expression levels of marker genes for defence signalling pathways. The extracts of *U. lactuca* and *S. filipendula* induced jasmonate signalling defence systems. However, *G. serrulatum* extract was able to sequentially induce both salicylic acid and jasmonate signalling pathways and, as a result, was found to be the most effective in controlling the intensity of both diseases. Local seaweed extracts therefore represent a good potentially environmental -friendly alternative for farmers of the Southern Caribbean to manage diseases caused by *A. solani* and *X. vesicatoria* in tomato.

23. Superelongation Disease in Cassava - Development of an Integrated Pest Management System for the Disease.

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Cassava is a vital staple and subsistence crop across the tropics with 20% of the 250 million tonne global annual production originating from Latin America and the Caribbean. In this region yields are threatened by the spread of the emergent Super-elongation disease (SED), which in 2007 began to infect cassava in Trinidad. In our research we are seeking to (1) Improve upon the current agricultural practices aimed at reducing the incidence and impact of SED by examining the effectiveness of existing fungicidal treatment regimes of cassava cuttings (2) Screen a library of natural antifungals and identify new bioactive compounds against *Sphaceloma manihoticola* (teleomorph *Elsinoe brasiliensis* the causal fungal pathogen) - for this purpose we have developed a screening assay to identify microbes producing bioactive compounds against the pathogen; and (3) Screen a collection of tissue cultured cassava genotypes *in-vitro* for resistance to the pathogen - for this purpose a recently developed biomarker for the pathogen *Sphaceloma manihoticola* is being used to follow disease progression in the collection of cassava varieties to determine resistance and susceptibility of the collection. Our preliminary results from our antifungal screenings have identified a few microbes producing bioactive compounds against *Sphaceloma manihoticola*. In addition to these, our MIC assays have identified some previously extracted natural antifungals displaying bioactivity against the pathogen.

24. *Ascophyllum* Seaweed Extract application causes reduction in disease levels in field Tomatoes

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The effect of *Ascophyllum* Seaweed Extract (ASWE) on tomato diseases was evaluated both under tropical field conditions and under greenhouse conditions in Trinidad. Applications of 0.5% ASWE as foliar spray at biweekly intervals resulted in significant reductions of tomato foliar diseases. Maximum reduction of diseases incidence was observed especially when rotated with fungicides (*Alternaria solani* by 63% and *Xanthomonas campestris* pv *vesicatoria* by 43%) in comparison with controls. A similar trend was also observed under greenhouse conditions. Fruit yields also increased up to 42% in tomato plants treated with ASWE. There were also significantly higher levels of defense enzyme activity (PPO, PAL, PO, Chitinase and Glucanase) and higher levels of phenols accumulated in plants treated with ASWE compared to controls. Upon investigating transcript levels of defense pathway marker genes, there was an upregulation of genes in the Jasmonic Acid/ Ethylene pathway. Disease reduction might be attributed to

induction of plant disease resistance in the plants treated with ASWE as well as enhanced plant growth and earlier recovery from infection.

25. Chitosan Bioelicitor based control of *Alternaria* and *Xanthomonas* infections in Tomato

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Chitosan, is a deacylated derivative of chitin has been used to promote plant growth and defense but the mechanisms by which it is able to do so are still unclear. In this study the commercial chitosan formulation (Armour-Zen®) was studied for its ability to control two important tomato pathogens: *Alternaria solani* and *Xanthomonas vesicatoria*. Experiments were also performed to study the mechanism of induced resistance by examining induction of enzymes and genes involved in plant defense. Applications of the chitosan extract significantly reduced the incidences of both diseases in greenhouse and field trials and also displayed a positive effect in growth and yields of tomato. Chitosan-treated plants also recorded elevated levels of defense enzymes and upregulation of the PIN II marker gene for defense signaling pathways when compared to the control. It was therefore proposed that chitosan would be able to provide broad-range protection through induced systemic resistance mechanisms.

26. Biocontrol potential of a *Burkholderia* sp against tomato soil borne fungal pathogens

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The biocontrol potential of a new *Burkholderia* sp strain-1 was evaluated under lab and greenhouse conditions. Tomato seeds when treated with the bacterial suspension, showed significant increase in germination percentage, root and shoot length and seedling vigour. The *Burkholderia* sp strain-1 produced several mycolytic enzymes (proteases, lipases, cellulases and glucanases) and inhibited the mycelial growth of *P. aphanidematum*, *F.o f.sp solani*, *R. solani* and *S. rolfsii* under in vitro conditions. A talc-based powder formulation of *Burkholderia* sp strain-1 was developed and evaluated for its efficacy in the management of tomato soil borne pathogens under greenhouse conditions. Seed treatment combined with soil application of the talc powder formulation of *Burkholderia* sp significantly reduced the incidence of damping off, wilt, root rot and Southern stem blight in green house conditions. Bacterial inoculation in plants led to augmentation of phenolic levels and upregulation of activities of defense enzymes including phenyl alanine ammonia lyase (PAL), peroxidase (PO), polyphenol oxidase (PPO), β 1,3 glucanase and chitinase in leaves and roots of tomato. The increase in phenolic levels and

enhanced defense enzyme activities in roots were observed up to 7 days after inoculation. The endophytic movement of *Burkholderia* sp. in the stem, roots and leaves of tomato was confirmed through PCR and the maximum concentration of growth of *Burkholderia* was observed in roots.

27. An investigation into the crop management methods adopted by farmers in Trinidad and Tobago.

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In the current study we have investigated the crop management methods adopted by farmers in various regions of Trinidad. In recent times the Government of Trinidad and Tobago has placed emphasis on farming so this study was done so that the crop management techniques of farmers in order for farming to become more environmentally friendly. Questionnaires containing both open ended and close ended interview type questions were handed distributed to 31 farmers across the country; these areas included Gasparillo, Tableland, Felicity, Endeavour, St Helena, Las Lomas, Arima, Brazil, Wallerfield, San Rafael and La Horquetta. It was determined that the use of synthetic pesticides is dominant as they are very effective in killing pests and managing disease. Farmers, depending on the area that they were from faced different difficulties such as getting land, irrigation issues or problems in acquiring labour. The questionnaire sought to get a comprehensive display of the farmers' knowledge in order to develop means of educating them so that their agriculture could be more sustainable. We have also studied the Simpson's diversity index in the sample fields. The majority of farms that were tested had low biodiversity because of the excessive application of pesticides, almost as frequently as twice per week, which did not give the environment time to recover. These pesticides also targeted organisms that were not pests, and were generally responsible for low biodiversity.

28. Integrated Disease Management of Pumpkin

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Pumpkins (*Curcubita pepo*) are a member of the Cucurbitaceae family and is widely cultivated throughout Trinidad and Tobago. Cultivation occurs annually though mainly during the dry season months because of the crop's resistance to drought. The fruit is not only consumed directly but also used in many food and beverage products. Pumpkin production in Trinidad is greatly affected by disease and pests which lower both yield and quality of the fruits. Current disease management practises rely heavily on chemical usage, which usually exceeds recommended levels by environmental protection and food safety agencies. Integrated disease

management involves the coordinated use of multiple tactics to control a disease that optimizes both economic and environmental factors. A three year study involving IDM in pumpkin was carried out across fields in Trinidad factoring chemical, biological, cultural and non – conventional control of pests and diseases. Diseases were monitored and scored for both severity and progression and the effects of the IDM on plant growth and fruit yield were also considered. The results of these would be presented.

29. *In Vitro* Antimicrobial Activity in stems of *Montrichardia arborescens* (Moco moco) and combined extract of *Montrichardia arborescens* stems and *Azadirachta indica* (Neem) leaves

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The antimicrobial activity of the ethanol and hexane extracts of the stems of *Montrichardia arborescens* (Araceae) and leaves of *Azadirachta indica* (Moraceae) and combined extracts were investigated against *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella pneumoniae* and *Candida albicans*. The extracts were prepared at different concentrations of (0.01g/L, 0.025g/L and 0.05g/L) and their antimicrobial screening was carried out using the Agar Disc diffusion method. These selected microorganisms were also tested against a standard antibiotic, Ampicillin (0.05mg/L). The *M. arborescens*, hexane extract showed the largest area of zone of inhibition (AZOI), of 283mm² against *E. coli*. The lowest AZOI of 31mm² was induced by the combined ethanolic extract against *K. pneumoniae*. Antimicrobial selectivity was also evident. The hexane and ethanolic extract of *M.arborescens* seems to be selective against *E. coli* and *C. albicans* respectively. The combined hexane and ethanolic extract of *M. arborescens* and *A.indica* seems to be more selective against *C. albicans*. Also, a decrease in antimicrobial activity was evident for the combined extracts. Thus, the extract of *M. arborescens* stem and *A. indicia* leaves can be used as natural therapeutic antimicrobial agents.

30. Attitudes, Knowledge and Practices of Trinidad Vegetable Farmers and their predisposition to adopting IPM strategies in the management crop diseases.

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The extension of integrated crop management advice to Trinidad farmers was the main objective of Plant Clinics that were established by Plantwise a global crop health programme. In Trinidad a series of eight clinics were implemented in 2013 in collaboration with the Ministry of Agriculture and the National Agricultural Marketing and Development Corporation. These clinics were poorly attended. In 2015 a study was conducted to understand the Knowledge, Attitudes and Practices (KAP) of the main producers and their attendance at the plant clinics. The survey was conducted with 40 clinic participants and 96 vegetable farmers. Respondent's

knowledge, attitudes and practices relating to pests and disease control; about pesticides and related information and sources of pest and disease information sources were assessed. Data from the questionnaires were analysed using SPSS statistical programme. The highest levels of knowledge (35-42%) were for knowing where to source information about pests and diseases and the harvest intervals of pesticides. 75.8% and 69.2% respectively agreed or strongly agreed that information from input suppliers were timely and reliable. While 42.7% and 55.9% agreed or strongly agreed that information from Ministry of Agriculture is timely and reliable. Farmers generally choose a pesticide based on effectiveness of control. More than half reported that they always use a cocktail of four or more pesticides to control multiple problems. The means for factors pertaining to environmentally safe and IPM friendly practices were ranged between 3.5-4 indicating that a fairly good appreciation among farmers of environmental issues and augur well for enhanced IPM training.

31. Integrated Disease Management of Cowpea (*Vigna unguiculata* L. Walp) in Trinidad

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The use of synthetic chemicals is common practice among farmers in Trinidad and since there are no laws in place to monitor their usage, they are often used in large quantities during a single growing season. Cowpea, a commonly grown vegetable crop in Trinidad which is susceptible to a number of diseases and viruses, is no exception to this practice. This research, using cowpea as a model, investigated the effectiveness of various Integrated Disease Management (IDM) strategies. The main aim of this study was to develop an IDM strategy that would be more sustainable and require less synthetic chemical input when growing this crop. To achieve this aim four (4) half acre field trials, in total, were set up with two (2) trials each conducted during the dry season and rainy season. The fields were treated with various combinations of cultural, bio-control, elicitor and chemical treatments at different stages of development. The fields were visited several times to undertake disease incidence scoring, which was done by employing a set scale. On completion of the trials, the data collected revealed that the IDM strategies implemented were more effective than the common techniques used by local farmers. The IDM strategies in this study can be conveyed to farmers as a possible option through which cowpea farming can become more cost efficient, environmentally friendly and thus more sustainable.

32. Pest and disease control in greenhouse hydroponic systems for tomato production

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Greenhouse-based hydroponic culture of tomato cultivation is an intensive production system becoming popular in Trinidad. Occurrence of pest and diseases is one of the constraints in

greenhouse conditions. In this presentation we will describe the schedule of operations followed to control diseases and pests and also to keep optimum growth and ensure maximum productivity.

33. Principles of IDM in vegetables.

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Vegetable production in the southern Caribbean is primarily taking place in an intensive manner mostly in small holdings wherein availability of resources including land, water, inputs and labour is available in limitation. The sustainability of production systems is less due to over-use and dependence of non-organic inputs on a wider scale. Chemical pesticides and fungicides are used very indiscriminately with less understanding of the long standing effects on the environment and residual toxicity in the produce. In any given situation the amount of chemicals can be significantly reduced without compromising the goals of plant protection. The cotemporary integrated disease management systems practised all over the world incorporates multiple approaches for disease control rather than relying mostly on chemical methods. Integrated Pest Management (IPM) as applied to vegetable diseases involves using all the tactics available to the grower (cultural, biological, host-plant resistance, field scouting, chemical) that provide acceptable yield and quality at the least cost and are compatible with the tenets of environmental stewardship, with priorities set on conserving the environmental sustainability and protecting consumers' health.

34. Carrageenans, sulfated polysaccharides from red seaweeds, affect tomato chlorotic dwarf viroid (TCDVd) replication and reduce symptom occurrence in tomatoes

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Carrageenans are sulfated polysaccharides that are abundant in red seaweeds (around 40% by dry weight). Based on the degree of sulfation, several groups of carrageenans such as iota(ι)-, kappa(κ)- and lambda(λ)-carrageenan have been described. Each type presents its own characteristic bioactivity including activation of plant defense mechanisms. Viroids are small, single-stranded, non-protein coding circular RNA molecules. Tomato chlorotic dwarf viroid (TCDVd) belongs to the genus *Pospiviroid*, family Pospiviroidae. Viroids from the genus

Pospiviroid are responsible for the occurrence of more than 25 diseases in agricultural, horticultural and ornamental plants. The aim of the study was to analyse the effects of three types of carrageenans (ι , κ and λ) on tomato chlorotic dwarf viroid (TCDVd) replication and symptom development in tomatoes. Three-week-old tomato plants were spray-treated with the three types of carrageenan at $1 \text{ g}\cdot\text{L}^{-1}$ and then, after 48 h, inoculated with TCDVd. λ -carrageenan was found to significantly reduce the development of viroid symptoms after eight weeks of inoculation. 28% plants showed distinctive bunchy-top symptoms as compared to the 82% in the control group. Tomato proteome analysis of λ -carrageenan treated plants revealed that the abundance level of 14 proteins was increased and that of 3 proteins was decreased. Real-time quantitative PCR analyses of the expression of jasmonic acid related genes, allene oxide synthase (*AOS*) and lipoxygenase (*LOX*) showed that these genes were up-regulated in the λ -carrageenan treatment during viroid infection. These results suggest that λ -carrageenan can activate several defense mechanisms in tomato that are efficient against TCDVd, including components of the jasmonic acid (JA) pathway. These beneficial effects prompt for further studies exploring the protective effects of carrageenans and of other marine bioproducts against viroid infection and for increased usage of these products in plant protection strategies.

35. Four Diseases that affects Fruits and Vegetables in the British Virgin islands (BVI) and the Integrated Disease Management Approach Utilized to Control these Diseases.

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Assorted vegetables and fruits production is cultivated in the British Virgin Islands. In recent years its production has declined. New initiatives implemented by the Government for 2015-2020 has created an avenue for an increase in the national production. The expected targeted production is an increase of 7% over the said period. Worldwide fruits and vegetables are affected by diseases that drastically reduce their production. Among them are downy mildew caused by *Pseudoperonospora cubensis*; powdery mildew caused by *Erysiphe pulchra*; anthracnose caused by *Colletotrichum gloeosporioides* and cercospora leaf spot caused by *Cercospora apii*. The aim of the study was to report the work conducted using Integrated Disease Management to aid in controlling the afore-said diseases. The main components of the Integrated Disease Management (IDM) program are prevention, monitoring, accurate disease diagnosis, development of acceptable disease thresholds and optimal selection of management tools.

Session 4: Poster Session

1. An investigation of the effectiveness of plant extracts from *Azadirachta indica* (neem) and *Persea americana* (pear) against rice sheath blight disease induced by *Rhizoctonia solani*.

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Biological controls of diseases have an important role in the effort to reduce the use of synthetic chemicals in controlling and preventing destructive rice diseases in Guyana. Leaves from *Azadirachta indica* (neem) and *Persea americana* (pear) plants were extracted selectively with solvents of increasing polarity: hexane, ethanol and water. These extracts were later diluted in concentrations of 0.10%, 0.25% and 0.50% and tested against the fungus, *Rhizoctonia solani*, isolated from infected plants. The antifungal effect of these extracts against the pathogen, *R. solani*, was then evaluated by the disc diffusion assay. Both plant extracts showed varying degrees of antifungal effect at different concentrations against the pathogen. Results indicated that pear leaf ethanol extract at 0.50% concentration with induced AZOI = 251.24 mm² was the most effective against *R. solani*, followed by neem leaf hexane extract at 0.50% concentration (AZOI = 195.5 mm²). Interestingly, the aqueous extract showed the same AZOI at all concentration for both neem (AZOI = 75.1 mm²) and pear leaf (AZOI = 57.5 mm²) extracts. Overall, neem and pear leaf extracts were determined to be effective biological control against the sheath blight of rice and their future application in the rice industry is pending.

2. *Bacillus* strains in healthy seedling production of tomato

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In tomato production, damping off complex is considered as more serious problem in tomato production under nursery conditions and responsible for severe losses during and after transplantation. Therapeutic approach of managing the diseases with chemical fungicides has been the prevailing disease control strategy for over several years. The indiscriminate use of fungicides led to the development of new resistant strains demanding more quantity of fungicides. Heavy and repeated applications of fungicides also results in eliminating beneficial microorganisms from the rhizosphere region and making the disease problems still more serious. Therefore it is believed that the establishment and maintenance of a threshold population of beneficial microbes could be effective in reducing disease in vegetable nurseries and in main field. In this context, the current study was carried out to explore the potential of indigenous novel microbial strains in the production of healthy seedlings in tomato. The rhizobacterial stains were isolated from various agricultural and forestry ecosystems of Trinidad. A total of 37 rhizobacterial strains were tested against *Fusarium* isolates from infected tomato seedlings *in-*

vitro as initial screening. Among all the strains, TM12, ML5 and OG2L rhizobacterial strains exhibited high inhibition against *Fusarium FoT* isolate. These strains were proved to be efficient in promoting germination, seedling growth and survival rate of tomato seedlings at the time of transplanting. PCR mediated 16s rRNA analysis revealed that strains TM12 & ML5 were *Bacillus amyloliquefaciens* while strain OG2L was identified as *Bacillus cereus*. These strains required further evaluation in the field conditions to understand its full potential in the management of tomato diseases.

3. *Bacillus* strains for biological control of anthracnose infection in mango

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Anthracnose (*Colletotrichum gloeosporioides*) is one of the most serious diseases affecting mango production at pre and post-harvest stages. The control of anthracnose is usually practiced by the application of fungicides. The concerns over use of fungicides have necessitated the development of an alternative and safe management practices. As an alternative to chemical control, biological control is considered as an effective, safe and sustainable for the control of postharvest diseases. In this context, the current study was carried out to evaluate the postharvest biocontrol efficacy of ten strains against anthracnose pathogen under *in-vitro* and *in-vivo* conditions. *C. gloeosporioides* was isolated from infected mango fruits. *Bacillus* strains were screened for their inhibition against the mycelial growth of *C. gloeosporioides*. *Bacillus* strains OG3 (55.60%) and OG2 (66.05%) exhibited higher inhibition against anthracnose pathogen compared to control. Further, the experiment was conducted in healthy mango fruits by artificial inoculation of *C. gloeosporioides* and by challenge inoculation of *Bacillus* strains OG3 and OG2 under *in vivo*. Mango fruits treated with *Bacillus* strains OG2 significantly reduced the lesion diameter (4.0 cm) and rotten pulp (9.30%) of anthracnose compared to untreated control fruits (4.5 cm; 14.85%). The present study has opened up avenues to explore the biocontrol efficacy of *Bacillus* strain OG2 in the management of anthracnose diseases in the tropical crop production systems.

4. Evaluating the Potential of Rhizobacteria for the Control of *Cercospora* Leafspot in lettuce

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Lettuce is a widely produced vegetable in the Caribbean and it generates income for farmers in short term vegetable crop production. Though the crop duration is short, the fungal disease caused by *Cercospora* spp. is considered to be a serious constraint in lettuce production. The application of fungicides has been the prevailing disease control strategy for management of *Cercospora* leaf spot in the region. The continuous and indiscriminate application of fungicides

especially in leafy vegetables like lettuce have been the major concern as it leads to the persistence of pesticide residues and development of resistance in the pathogen. Considering this scenario, it is necessary to develop the alternate strategies which could reduce the application of pesticides and ensure the production of quality food. In this regard, the development of biological control strategies has gained attention in this study. The current study focused on identifying beneficial rhizobacteria that are able to antagonize the pathogen *Cercospora* which causes leafspot disease in lettuce. Nearly 200 rhizobacterial strains were isolated from different agricultural ecosystems of Trinidad. All the rhizobacterial strains have been tested for their antagonistic activity against *Cercospora* isolated from the infected lettuce samples. Of 200 rhizobacteria strains, 64 strains inhibited the fungal growth in dual culture technique. Among 64, ten rhizobacterial strains such as Bs CHAG 1D, TAB 3C, PRIN 2F, CUN 4F, CUN 4E, PRIN 2A, TAB 3A, PRIN 1A, PRIN 2D, and PRIN 2B proved to be more effective and accounted for more than 50% inhibition of the fungal pathogen *in vitro*. The biochemical and molecular characterization of the strains revealed that most of the rhizobacterial strains were *Bacillus*. Further research is in progress to test the efficacy of elite rhizobacterial strains under cultivation conditions and to understand the mechanisms involved in the control of leaf spot pathogen.

5. Black mould disease affecting okra cultivation in Trinidad

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Okra (*Hibiscus esculentus*) is one of the most important vegetable crops cultivated in Trinidad. The cultivation of this crop is affected by occurrence of various pests and diseases. Of several diseases, the incidence of foliar disease appears to be a major problem in commercial cultivation of Okra. The leaf samples showing black coloured spots in okra plants were widespread in farmers' field in the location of Orange Grove area. The infected leaf samples were collected from the farmers' field for further diagnosis in the Plant Pathology laboratory. The symptoms were black in colour that predominantly appeared on lower side of the leaves. The infected leaf samples were used for isolation of the pure culture. The fungus isolated from infected leaf samples showed elongated, cylindrical and *Cercospora* conidia produced typically from clustered conidiophores with 5 to 7 septations. The widespread occurrence of this *Cercospora* leaf spot disease has further triggered our research interest to study its impact on yield and to device the suitable management strategy for the successful cultivation of okra.

6. Superelongation Disease in Cassava- Development of a disease model using in vitro cultured plantlets.

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Cassava (*Manihot esculenta* Crantz) is an economically important tropical cash crop grown in Latin America, the Caribbean and Africa. However, the prosperity of this crop in the Caribbean is threatened by 'Superelongation disease' (SED), caused by the fungal pathogen *Sphaceloma manihoticola* (teleomorph: *Elsinoe brasiliensis*), a gibberellin (GA)-producing fungus. Symptoms of this disease include necrotic lesions, leaf curling, and in severely infected plants, increased elongation of internodes ultimately resulting in dieback and defoliation. Here, we report the proposed development of a SED disease model using tissue cultured cassava plantlets to test the effectiveness of natural product antifungal application to SED susceptible cultivars, further investigate the physiological mechanism of SED resistance in resistant cultivars, and therefore implement an efficient Integrated Disease Management scheme for this crop.

7. Coping with Stress: Strategies for drought and flooding tolerance in pigeon pea.

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Pigeon Pea (*Cajanus cajan*) is an important agronomic crop well known for its natural drought resistance. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has been at the forefront of a great body of work on the physiology and general characteristics of the shoot and root system of this crop. However, the recent release of a searchable database for pigeon pea genome should now facilitate the exploration of molecular and genetic strategies for crop improvement. Using a mini-pigeon pea germplasm donated by ICRISAT, we intend to (1) investigate the natural variation in root architecture under conditions of water stress and flooding and (2) Identify molecular markers for a GWAS mapping approach to determine QTL(s) associated with drought tolerance and/or flooding tolerance. These approaches should allow us to develop lines with features desirable and beneficial under these water stressed conditions.

8. Molecular and Phenotypic Diversity of Caribbean isolates of *Puccinia kuehnii*, the orange rust pathogen of sugarcane.

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A study was conducted to determine the diversity of *Puccinia kuehnii*, the causal agent of orange rust disease of sugarcane, in the Caribbean. *P. kuehnii* isolates were obtained from four major sugarcane cultivators and sugar exporters in the Caribbean viz. Belize, Dominican Republic, Jamaica and Guyana. Urediniospore morphology (length, width and size) was normally distributed and ANOVA revealed significant differences ($P < 0.001$) between the isolates although these were not associated with geographic origin. Pearson's product moment correlation between urediniospore length and width was not significant ($r = 0.46$, $P > 0.05$),

however, correlations between length/ width and size (length x width) were highly significant ($P < 0.01$) with $r = 0.81$ and 0.89 , respectively. Molecular genetic analyses suggests very little diversity among the Caribbean *P. kuehni* isolates and DNA sequence analysis of amplified ITS regions of ribosomal DNA, clustered the isolates together with previously reported *P. kuehni* and other fungal rust isolates of sugarcane.

9. Natural variation in lignin and suberin composition in sugarcane: Effects on animal digestibility and fungal pathogenicity.

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Plants have thick cell walls rich in lignin. Most of this lignin is deposited in the vascular bundles of stems and leaves as well as in some non-lignified tissue [1]. The quantity of lignin in these tissues increases with the developmental age of the plant and the increased deposition of lignin results in thicker cell walls making them much harder to degrade. Sugarcane biomass is utilized in some animal feed products mainly for ruminants (animals that tend to chew food several times over before swallowing). They are able to digest the material due to close associations formed with rumen bacteria that degrade the lignified plant cell walls [2]. However, high amounts of lignin have been associated with decreased digestibility by ruminants [2]. The same has been noted for suberin (a waxy substance mainly found in sugarcane cell walls, leaf blades, sclerenchyma cells stem and cork cells) composition in sugarcane tissues.

Puccinia kuehni, is the causal agent of the foliar disease, orange rust of sugarcane and little is known about the mechanism of resistance/susceptibility of different sugarcane varieties to this disease. In this study, we propose to investigate the natural variation in the lipid and phenolic polymers (cuticle, suberin, and lignin) in a collection of sugarcane varieties. We will undertake careful chemical quantification of the samples by GC-MS/FID and to also follow them microscopically using SEM/TEM of cuticle. Confocal microscopy of suberin deposition using the suberin-specific stain fluoral yellow 088 would also be performed.

10. Effects of *Ascophyllum* seaweed extract on tomato growth, yield and fruit quality

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Tomato plants grown under greenhouse and field conditions were treated with *Ascophyllum* Seaweed Extract (ASWE), to evaluate methods of application, dosage applications as well as the impact on plant growth parameters, fruit quality and fruit yields. Plants sprayed with 0.2% ASWE had significantly increased plant height (10%) and fruit yields (17%) compared to control plots. Plants sprayed with 0.5% ASWE resulted in an even greater significant increase in plant

height (32%) and fruits yields (63%). Greenhouse experiments showed that 0.5% ASWE also caused significant increases in plant height (20%) and fruit yields (54%). ASWE treated plants generally had larger root systems, increased concentrations of minerals in shoots and significant increases in fruit quality attributes including size, colour, firmness, total soluble solids, ascorbic acid and minerals. Overall, the use of ASWE resulted in improvements in tomato plant growth, fruit yields and fruit quality under growing conditions in Trinidad.

11. Occurrence and Biocontrol of Cowpea (*Vigna unguiculata*) root diseases in Trinidad

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Cowpea (*Vigna unguiculata*), one of the most widely grown legumes on the island nation of Trinidad, is a relatively fast growing and versatile crop. This crop, which is commonly referred to locally as “bodi” is susceptible to various bacteria, fungi and viruses that cause a variety of foliar and root diseases. In this investigation, field and greenhouse experiments were utilized to score disease incidence and to test the efficacy of treatments. In order to identify and score the incidence of disease in this crop several test fields were set up in strategic locations across the island of Trinidad. The field trials were carried out during both the dry and wet seasons and consisted of single and combination biocontrol treatments of *Trichoderma viride*, *Pseudomonas* spp., and *Bacillus subtilis*. For the greenhouse trial emphasis was placed on the treatment of several fungal root diseases namely, *Sclerotium rolfsii* Sacc., *Fusarium oxysporum* f. sp. *tracheiphilum*, and *Pythium aphanidermatum*, with the identical biocontrol agents utilized during the field trials. The Percent Disease Incidence (PDI) for the field trials over both the wet and dry seasons was lowest for each root disease when treated with a combination of each bio-control agent (TV1+Bs1+Pf1).

12. In vitro antimicrobial activity of solvent extracts of seaweeds against plant pathogens

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Seaweeds are marine macroalgae which are rich sources of novel compounds which possess an array of bioactive potential. They have been shown to hold key compounds that have both antibacterial as well as antifungal activity. This study aims at investigating the antimicrobial activity of several seaweeds attained from the coast of Trinidad on several plant pathogens. The seaweeds to be screened includes the Phaeophyta (*Sargassum filipendula*) and the Rhodophyta group (*Acanthophora spicifera* and *Gelidium serrulatum*). These three seaweed species will undergo solvent extraction which includes methanol, ethyl acetate and chloroform. These solvent extracts will then be tested for antimicrobial activity using the fungal inundation and disc diffusion assays on plant pathogens which cause some of the most destructive diseases in some

major crops cultivated in Trinidad. These pathogens include; *Alternaria solani* (early blight), *Septoria lycopersici* (leaf spot), *Phytophthora infestans* (late blight), *Sclerotium rolfsii*, *Xanthomonas campestris pv. Vesicatoria* (bacterial leaf spot) and *Xanthomonas campestris pv. Campestris* (black rot). Upon screening, the solvent extracts which shows the best inhibitory activity would be used to isolate and identify the bioactive molecules present by means of chromatographic and spectroscopic analysis. This research can shed light into compounds present in seaweeds which can be exploited for further antimicrobial research.

13. Optimization of multiplex PCR for the detection of three viruses causing severe mosaic in pumpkin

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Pumpkin is one of the most important agricultural crops in Trinidad. For the past three years from 2013 we have noticed severe symptoms throughout Trinidad such as severe mosaic and yellowing on leaves and severe deformation on pumpkin fruits. The disease symptoms were recorded at all the growth stages with maximum incidence of 74%. The leaf samples from 10 symptomatic plants were collected from the farmer's field located at Barrackpore (4 samples), Waterloo (3 samples) and Orange groove (3 samples). The RNA and DNA was extracted from all the samples and RT-PCR/PCR was carried out with potyvirus, begomovirus and cucumovirus specific primers. The strong amplicons are obtained for all the samples for Zucchini yellow mosaic virus (ZYMV) with ZYMVcp-for/ZYMVcp-rev primers targeting ~1100bp of coat protein region. Seven of ten samples were amplified with Squash mosaic virus (SqMV) with SqMV RNA2-F1/SqMV RNA2-R1 primers targeting 582bp of RNA-2 region. Similarly four samples were amplified with Cucumber mosaic virus (CMV) with CMV-F/CMV-R primers targeting ~530 bp coat protein region. Further the optimization of multiplex PCR was carried out to detect all the three viruses in a single PCR and multiplex- RT-PCR was found to be equally efficient to uniplex-RT-PCR to amplify the target viruses from Pumpkin. This is the first report on detecting three viruses together in a single PCR reaction in pumpkin from Trinidad and this will have immense application in pumpkin quarantine programs.

14. Antimicrobial activity of marine sponges and their associated bacteria from the North coast of Trinidad

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For this project, 16 sponges were collected from four different areas along the North coast of Trinidad. Bacteria were then isolated using two different media types. Crude extracts were obtained via solvent extraction of 6 sponges and isolated sponge bacteria were grown in broth. Screening was then done via spot plating of both the crude extracts and the broth cultures against

seven human and three plant pathogens. Inhibition zones were measured in millimeters. It was observed that 2 out of the 6 sponge crude extracts and 11 out of 200 isolated bacteria were seen to have antimicrobial activity against one or more of the pathogens tested. It was observed that both marine sponges and their associated bacteria are potential sources of antimicrobial activity. The observed antimicrobial activity might be due to secondary metabolite production of the sponges and bacteria as part of their survival mechanisms.

15. An Economic Analysis of Vegetables Volume and Price Behaviour in Trinidad and Tobago

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The prices of vegetable and the volumes of their arrival are the major determinants of consumer food choices and, in turn, dietary quality. Vegetable prices and volume vary across Trinidad and Tobago, but until now, an analysis that provides a consistent and statistically detailed measure of prices and volumes did not exist. Consequently, this study was planned to examine the behaviour and pattern of fluctuations in prices and arrivals of 22 major vegetables consumed in Trinidad and Tobago, using monthly data for a period of 10 years from 2006 to 2015 obtained from the National Agricultural Marketing and Development Corporation (NAMDEVCO). The seasonal indices were worked out by using ratio to moving average decomposition method which was followed by the evaluation of seasonality. Besides, the nature of relationship between market arrivals and prices was analysed using lag-linear model. The results revealed that the seasonality was high (38.71 per cent) in the arrival of large melonegene and the low (11.79 per cent) in medium sweet peppers arrival to the market. However, the seasonality in price was more (53.68 per cent) in christophene arrival, while it was less (11.96 per cent) in green plantains. The results of lagged linear models indicated that past prices and volumes were important factors that determine the current prices and the marketed volumes in many vegetables.

16. Control of brown spot (*Bipolaris oryzae*) disease in rice using a biological control agent *Trichoderma viride*

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Rice is one of the main source of carbohydrate that is grown and consumed worldwide and also on of Guyana rapid growing industry and contribute largely to Guyana export market. Rice is one of Guyana's major exports and it is staple food for a large parts of the world's human population. It is the grain with the second-highest worldwide production after corn.

The rice industry in Guyana gas continued to make a significant contribution to the country's economy and has surpassed sugar as the most productive agricultural industry (GRDB Annual Report, 2011). Fungal infection is one the rapid and leading disease problems facing in Guyana in the rice industry. In the case the diseases need to be controlled in order to maintain a good

standard quality and adequate food supply. Biological control is an innovative, cost effective and eco-friendly approach for control of rice diseases. *Trichoderma sp.* is known for its mycoparasitic and antagonistic mechanism for the control of wide range of fungal disease in all types of crops. *Trichoderma sp.* is an ecofriendly organism that does not cause any harmful and side effect on human beings and domestic animals when handled. This research is based on the principle of biological control of fungal diseases brown spot in rice plants by the use of *T. viride*. Cultures of *T. viride* were collected and isolated from rice cultivated soil and were used in laboratory condition for the control of rice diseases of brown spot (*Bipolaris oryzae*). A completely randomized experimental design was used. The results indicate that with application of the *T. viride* there was no increase in the vegetative growth characteristic of the rice plants, however the *T. viride* was effective in reducing disease incidence.

17. Behaviour of market volumes and prices of root crops: The case of Trinidad and Tobago

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Root crops are important staples in Trinidad and Tobago shown by the total traded volume of 60 million (mn) kilograms (kgs) during the period 2006-2015. Sweet potato was found to be the most traded with an average volume of 1.6 mn kgs, this was followed by carrots and dasheen with respective volumes of 1.4 mn kg and 1mn kg. However, fluctuations have been observed in the main wholesale market and as a result prices were unstable which could have negatively impacted consumers and producers. Therefore, this study seeks to analyse the behaviour of root crop market volumes and prices. Specifically, carrots, cassava, yam, dasheen, eddoes, sweet potato and ginger. Monthly volume and price data for both local and imported root crops were collected from the National Agricultural Marketing and Development Corporation (NAMDEVCO). Linear growth rates were calculated using trend analysis of the ten root crops while the coefficient of variation along with the minimum and maximum prices assessed price spreads. The highest growth rate in the price was found in ginger (0.158) and the lowest in sweet potatoes (0.015). However in case of volumes, the highest growth rate (993.14) was seen in the arrival of sweet potatoes, while a negative growth (-153.38) was noticed in cassava. Besides, seasonality index was worked out using moving average decomposition method and lagged prices were tested to identify any relation with current prices. The results of this study could be used to guide policy decisions and production planning towards market stabilization.

18. *Sterptomyces spp*: A potential biocontrol agent for the management of black rot of cabbage incited by *Xanthomonas campestris* pv. *Campestris*

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Black rot (*Xanthomonas campestris* pv. *campestris*) is an important destructive bacterial disease of cabbage and its reduced the yield upto 67 per cent in severe cases. The intent of current study was to evaluate the different biocontrol agents viz., *Streptomyces exfoliatus*, *Streptomyces violaceusniger*, *Trichoderma asperellum* and *Pseudomonas fluorescens*, in addition plant extracts, organic amendments and plant oils against black rot disease under *in vitro* conditions. The effective bioagents evaluated against field conditions. The results of the field experiment revealed that the treatment, seed treatment with *Streptomyces exfoliatus* @ 10g/kg plus soil application of neem cake @ 150 kg/ha plus foliar application of *Streptomyces exfoliatus* @ 0.2 per cent showed least disease incidence of 12.78 PDI where as in unsprayed control recorded 62.78 PDI. The same treatments also recorded the highest yield of 51.25 t/ha and control recorded 19.44 t/ ha with cost benefit ratio of 1:7.7. Hence, the present investigation suggests that application of *Streptomyces exfoliatus* either individually or in different combinations of methods of application along with organic amendments significantly reduced the disease incidence under field conditions. In the other hand it helps to increase the cabbage yield and act as a potential biological control for sustainable management of black rot disease in cabbage.

19. Pre-harvest Factors affecting Post-harvest Diseases of vegetable Crops in Jamaica

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In Jamaica, as in many other developing countries, the effects of pre-harvest factors on postharvest diseases are often underestimated or even ignored. Consequently, many decisions made by the farmers during crop production greatly influence the postharvest quality of vegetables. The main pre-harvest factors affect the postharvest serious damages caused by diseases during the postharvest handling of vegetables in Jamaica, we could cite the limited varieties of resistant seeds and pest infestation, while soil fertility is less affecting these issues. To address or at least mitigate the issue, farmers are importing different seeds that are resistant to diseases, and also improving the fertility of their soils by using specific fertilizers that correct the deficiencies of their soils, rather than fertilizing in a traditional manner.

20. A study of yield and its components, genetic and interrelationships between components towards improving yield in hot pepper (*Capsicum chinense*).

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Caribbean aromatic hot pepper (*Capsicum chinense*) plays a pivotal role in imparting pungency and flavor to cuisines in the region. In Trinidad and Tobago it is utilized in the fresh and processed forms and has become an important cash crop with considerable export potential. Despite the enormous international market demand for local hot peppers, production has

declined over the years due to high cost of production and poor profitability. The major constraint to hot pepper production is the low yields. Hot pepper (*C. chinense*) production in the Caribbean is based on uncharacterised land races with very low yield potential, (*C. chinense*) ranging between 12-20 tonnes per hectare compared to *Capsicum annuum*, which can yield well over 100 tonnes per hectare. The objective of the study was to understand the yield components in *Capsicum chinense* and their genetics towards supporting a breeding programme aimed at improving yield. The study involved two experiments involving 86 accessions from the University of the West Indies (UWI) pepper germplasm collection (representing primarily Trinidad and Tobago, Colombia, Brazil, the Lesser Antilles and the Greater Antilles), to determine the yield components and their relationship to yield in hot pepper (*Capsicum chinense*) using correlation analysis, path coefficient analysis and principal component analysis. In the first experiment 86 accessions were evaluated for a number of yield components (average fruit weight, yield, total number of fruits harvested, total number of clusters per accession, average number of fruits per cluster, number of flowers per node, average number of fruits per cluster, reproductive efficiency, fruit dry weight, shoot dry weight, total dry weight and harvest index) and quality traits (fruit length, fruit width, colour and texture). In the second experiment 22 accessions from the previous study with superior quality traits and yield components were selected and evaluated. The study showed that the genotypes exhibited a wide range of variability for yield, yield components and quality traits studied ($p < 0.001$); and were highly heritable under the experimental conditions. The characters such as fruit number, number of clusters per plant and shoot dry weight recorded very high heritability and genotypic coefficients of variation with high expected genetic gains. Correlation analysis revealed that yield was positively correlated with total number of fruits harvested, total number of clusters per accession, average number of fruits per cluster, shoot dry weight, total dry weight and harvest index. Path coefficient analysis revealed that average fruit weight, total number of fruits harvested, total number of clusters per accession, and shoot dry weight had high positive direct effect on yield. Principal component analysis indicated that the first four principal axes accounted for over 80% of the total variation. The mean contributions of yield attributing characters total number of clusters per accession, total number of fruits harvested, average fruit weight, and harvest index were relatively high in the principal component axes #1 affirming their contribution to the total variation and fruit yield. Based on the identification of the important yield components and quality parameters in this study it is proposed that for the PhD two approaches would be used, diallel analysis and generation mean analysis, to understand the combining ability and genetics of these traits. The present work along with the future proposed work will provide the fundamental basis for *C. chinense* breeding in the Caribbean.

21. Use of some botanicals and Fungicides in the Management of fruit rot of chilli Caused by *Colletotrichum capsici* (Syd.) Butler and Bisby

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Chilli is an important commercial condiment crop extensively grown in our country. This crop is affected by many diseases among which fruit rot infect considerable loss both in yield and

quality. The fungus *Colletotrichum capsici* (Syd.) Bulter and Bisby is commonly associated with this disease. The disease was severe in all the major chilli growing areas of southern parts of Tamil Nadu. Of the 7 fungicides, 8 plant oils and 6 oilcakes tested *in vitro* by poison food techniques. Mancozeb (0.2 %) totally inhibited the mycelial growth and in pot culture experiment Mancozeb (0.2 %) reduce disease incidence drastically. Palmarosa oil and citronella oil 0.05 and 0.1 per cent concentration was found to be cent per cent inhibition of the mycelial growth *in vitro* condition. Out of six oil cakes tested the illuppai oil cake (10 %) has effectively controlled and inhibited the mycelial growth of the pathogen *in vitro*. Based on the effectiveness of plant products under *in vitro condition*, leaf extracts of 10% *Acorus calamus*, *Aegle marmelos*, *Abrus precatorius*, *Ocimum sanctum* and *Prosopis juliflora* were selected and tested against the disease in pot culture. The results revealed that two sprays of *Acorus calamus* rhizome (10 %) (50.44%) extract and *Aegle marmelos*, (50.4%) *Abrus precatorius* (50.4%) *Ocimum sanctum* and *Prosopis juliflora* leaf extracts (10%) first on 105 DAS and the second on 120 DAS. The botanicals also compatible with *Pseudomonas* and *Bacillus* spp and utilization of fruit rot disease control and pot culture and field experiments.

22. Molecular characterization of copper resistance in *Xanthomonas Campestris* pv. *campestris* strains indigenous to Trinidad, Trinidad and Tobago, W.I.

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Copper based fungicides and pesticides are ubiquitous in farming practices worldwide, from domestic to large scale commercial farms. Decades of use has led to the emergence of plant pathogenic bacteria resistant to toxic levels of copper in the environment, confounding efforts to reduce bacterial related pathogenesis in crops. The molecular mechanisms responsible for this phenomena of copper resistance have been characterised in phytopathogenic bacteria since the 1970's. Early work showed that the key genes responsible are typically borne on conjugative plasmids, with some chromosomal homologues identified. These genes are known as *cop* genes, with *copA* being highly conserved among many bacterial species and is used as a genetic marker for copper resistance. The extensive use of copper pesticides coupled with plasmid borne *cop* genes has ensured a wide spread and diversity of copper resistance genes in local bacterial populations. The local environmental conditions in Trinidad offers unique chances for genetic diversity to flourish in terms of copper resistance genetic determinants. This has been seen in previous work with *Xanthomonas campestris* pv. *campestris* , where novel versions of three plasmid borne *cop* genes were identified. This bacterial pathogen targets cruciferous vegetables and is the cause of the black rot disease which negatively impacts crop production in this country. This study seeks to characterize the levels of copper resistance of *Xanthomonas campestris* pv. *campestris* and evaluate the diversity and molecular mechanisms responsible for this phenomena.

23. Management of Yellow Vein Mosaic Disease transmitting vector, *Bemisia tabaci* (Aleyrodidae : Hemiptera) in bhendi.

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Field bio-efficacy of five insecticidal molecules with one neem product was evaluated against Bendi Yellow Vein Mosaic Virus transmitting whitefly, *Bemisia tabaci* (Aleyrodidae: Hemiptera) for two consecutive kharif seasons during the year 2012 and 2013 in a randomized block design (RBD) with four replications. The results expressed that the seed treatment with imidacloprid 70 WS 7.5g/kg of seed + foliar spray of thiomethoxam @ 0.25g/l was found to be highly effective by suppressing whitefly population minimize the BYVM incidence upto 78 per cent with the higher yield of 61.5q/ha with the CB ratio of 2.45 when compared with other insecticidal molecules and azadirachtin.

24. Unique genotypes of *Ralstonia solanacearum* affecting bananas in the Caribbean.

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Moko disease of banana, caused by *Ralstonia solanacearum* (Rs), has been a major threat to banana plantations throughout the islands and bordering countries of the Caribbean Sea. More recently, typical Moko symptoms were reported in Jamaica (2003), and in several parishes of St. Vincent, the neighboring island of Grenada (2006). To assess the phylogenetic diversity of the Moko-inducing Rs populations currently prevalent in the Caribbean, we surveyed banana plantations of Grenada (2007), Saint Vincent (2008), Guyana and Trinidad (2009). Bacterial colonies isolated from stem and tissue sections were mucoid, bird-eye shaped, and beige with a red center on modified SMSA medium and Kelman's modified medium. Phylotype-specific and "Moko"-specific multiplex PCRs identified all strains as *Ralstonia solanacearum* phylotype II, sequevars 4 or 6. Partial sequences of the *egl* and *mutS* genes allowed to position the strains within the phylotype-Clade system, and were deposited in Genbank under Accession Nos. KU708032 to KU708206. All Moko-inducing strains sampled in Guyana (n=4), Grenada (n=49) belonged to one unique Sequence Type (ST) within Phylotype IIA-Clade 2: *egl* ST001 (sequevar 6), *mutS* ST001. Interestingly, the strain IMI391743f, isolated from Jamaica in 2004, was also PCR-typed as phylotype IIA-Sequevar 6, like two Moko strains collected in Venezuela. However, Moko-inducing strains collected in St. Vincent mostly belonged to the phylotype IIB-Clade 4, *egl* ST016 (sequevar 4), *mutS* ST003, with only two IIA-Clade2 -eST001 (sequevar 6)-mST001 and one IIA-Clade 2-eST027 (sequevar 35)-mST001. This is the first report of the RSSC diversity currently prevalent in Caribbean banana plantations. In comparison to earlier reports, these findings suggest that the actual epidemiologically active Moko-inducing populations in the Carribeans are dominated by IIA-Clade 2, sequevar 6 strains. Moreover, the Moko strains recently introduced in St. Vincent most likely did not originate from Grenada.

25. Assessment of native seaweeds for phytostimulant and phytoelicitor properties in tropical vegetable crops.

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The application of agrochemicals to tropical crops leads to the build-up of harmful chemical residues in food produce, the development of chemical resistance by pathogens and pests, production costs escalation and huge environmental concerns. However, an alternative exists, whereby, farmers can utilize seaweed products since it has been reported that seaweeds possess various phytostimulant and phytoelicitor properties. This research aims at assessing the effects in which seaweeds native to the coasts of Trinidad play in promoting an overall increase in growth and yield of a major crop cultivated in the country. This research aims to use alkaline extracts of the seaweeds which include Chlorophyceae (*Caulerpa serrulata*, *Codium taylorii*), Rhodophyceae (*Gelidium serrulatum*, *Acanthophora spicifera*) and Phaeophyceae (*Sargassum filipendula*) and assess growth and yield parameters on both greenhouse and filed trails. qPCR would also be done to quantify the expression of genes involved in growth responses such as genes involved in auxins, cytokinins, gibberellins, abscisic acid synthesis and catabolism, genes involved in SA/ET/JA biosynthesis, pathogenesis-related proteins and antioxidant genes. An assay of defense-related enzymes such as phenylalanine ammonia-lyase, peroxidase, polyphenoloxidase, chitinase, β -1, 3 glucanase and total phenolic content would also be conducted. This investigation would unravel the mechanisms of plant growth promotion exhibited by local seaweed extracts compared to the commercially available *A. nodosum* and identify key seaweed species which are best suited for agricultural exploitation. The results from the study can also pave way to the development of green agriculture in Trinidad and Tobago.

26. Effects of seed priming with seaweed extracts on germination performance and foliar applications on growth using tomato and bell pepper under salinity stress.

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Salinity stress is a major abiotic factor which negatively affects the agricultural sector. However seed priming can help with seeds which are sown in soils with the unfavourable abiotic condition. Seed priming is a physiological technique which can be initiated as a means to improve seed performance as well as it initiates earlier and more uniform germination. It refers to soaking seeds in either water (hydropriming) or in some sort of solution aided with minerals (osmopriming). There can also be solid matrix priming where seeds are incubated in an insoluble, solid medium. This method can easily be adapted by farmers to benefit their crops. The research is focused on priming tomato and sweet pepper seeds, two major crops cultivated in Trinidad, in several locally sourced seaweeds. The seaweeds include Chlorophyceae (*Caulerpa serrulata*, *Codium taylorii*), Rhodophyceae (*Gelidium serrulatum*, *Acanthophora spicifera*) and Phaeophyceae (*Sargassum filipendula*). Alkaline extracts would be prepared from all mentioned

species and used as the primers. The seeds will be soaked in each extract for 12 hours then placed in petri dishes to observe germination performance under various concentrations of salt stress. Recordings would take place each day for up to 14 days. Parameters such as total seed germination rate, mean germination time, germination energy, germination index, seedling vigour, and plant height, shoot length, root length and root and shoot fresh and dry weights. Additionally a greenhouse trial will take place using both tomato and sweet pepper seedlings to determine the effects of foliar applications under various concentrations of salinity stress. Some variables that would be recorded includes; plant height, chlorophyll content, dry weight ratio and Na^+/K^+ ratio in root and shoot. Assays will also be done to determine antioxidant enzyme levels and qPCR to quantify the expression of upregulated genes under salt stress conditions.