CARIBBEAN FOOD CROPS SOCIETY

51

Fifty-first Annual Meeting 2015

Paramaribo, Suriname
Volume LI

PROCEEDINGS

OF THE

51ST ANNUAL MEETING

Caribbean Food Crops Society
51ST Annual Meeting
July 19 – July 24, 2015

Royal Ballroom Hotel Torarica,
Paramaribo, Suriname

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"Food Safety, Innovation and Quality in Green Agriculture: The Way Forward to Food Security for the Caribbean"

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Welcome remarks
by
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Professor Dr. Henry Ori, President CFCS 2015
Dr. Wilfredo Colón, Chair and CEO CFCS
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Dr. Raul Machiaveilli, Dean and Director of the College of Agriculture, University of Puerto Rico
Dr. Ryan Sidin, President of the Board of the Anton the Kom University of Suriname

Distinguished Guests,
Dear Collogues,

I would like to welcome you at the 51st annual conference of the Caribbean Food Crops Society in Paramaribo, Suriname. I am pleased to notice that the invited guests are present. I would also like to thank the international institutions, government organizations, non-government organizations, and all national institutions for accepting this invitation. This conference which is hosted by the Anton de Kom University of Suriname and the Ministry of Agriculture and Husbandry is organized by the CFCS. The CFCS is a Caribbean regional forum for scientists in agriculture with 51 years of experiences. This meeting is hosted after 38 years in Suriname, and is therefore a huge challenge and privilege for the Local Organizing Committee to uphold a top-notch conference and meet the expectations of all conference participants.

The organizing committee is extremely pleased to host this prestigious event in Suriname, a beautiful country in South –America which is rich in natural resources (e.g. the amazon rain forest, water, and land), history, cultural diversity, and heritage. The Annual Meeting will consist of one main theme key note address, eight sub-theme key note presentations, and 10 sequential sessions on a variety of topics. During this conference, Caribbean scientists from all over the world will have an opportunity to meet with other scientists and present the results of their studies, as well as engage with each other in collaboration to advance Caribbean agriculture.

As an addition to the conference program, four field trips are scheduled in different agricultural parts of the country according to specific interests of the conference participants. Experimental facilities of agricultural institutions, production farms, and exhibitions will be visited with additional cultural and social programs. A farmer's forum titled: **'Adoption of knowledge and appropriate technology by small farmers and women's organizations in rural areas in Suriname'** will be also held. The goal of this program is to identify approaches for adoption of knowledge/technology to the target groups and provide them with solutions, based on what they need.

The Theme of the conference is: **‘Food safety, Innovation and quality in a Green Agriculture: The Way forward to Caribbean Agriculture’**.

His Excellence, Distinguished Guests,
Dear Collogues,

Suriname is blessed with a lot of natural resources (tropical forest, fertile land, natural water bodies), rich culture, and biodiversity. The food production systems in the world are under increasing pressure to allow the world to meet sufficient, safe and healthy food, while at the same time their vulnerability increases. Climate change and loss of biodiversity are seen as a growing problem for decades but is not universally perceived as urgent. However, the probability of a radical, irreversible and possible disastrous change, as a result of the absence of adequate measures, is increasing. If we want to improve global and local food systems, including a focus on the availability of essential nutrients in it, it is necessary to innovate. The complex challenges that we face are asking for an integrated approach. To meet adequate, safe and healthy food does not only requires sufficient production, but also an adequate organization of the availability of food to consumers which requires a production that makes sustainable use of available natural resources and understanding the social environment and the behavior of the people who work with those processes. We need to prepare our future and provide the new generation with a green agriculture where food safety, innovation and quality are the vehicles.

This forum provides us with the opportunity for sharing our presentations with each other, and discussing important issues including Food Safety, Biotechnology, Soil management, Green revolution with each other over the next 3-4 days.

I hope that at the end of the conference we will be able to make decisions that will be useful to forward Caribbean Agricultural development.

I look forward to listen to all your presentations.
Thank you

Opening Speech at the 51st Annual Conference of the CFCS
by
Prof. Dr. Henry R. Ori, President CFCS 2015

Honourable Minister,

Distinguish guests, Ladies and Gentlemen,

Welcome and good morning

First of all I would like to thank the Minister of Agriculture for his presence to officiate the meeting. It is with great pleasure that I speak as President on behalf of the local Organizing Committee Of this Conference. It is with equal pleasure that I note the attendance of delegates from all the member countries of CFCS. This shows the importance attached to the Society by member countries and demonstrates the importance attached by you in supporting its activities through our Annual Meetings. Producing food is the primary role of farmers and the delivery of high-quality food and food traceability should be looked upon as public interest.

The challenges facing the food industry are well documented. From adapting to the effects of climate change, to feeding a growing global population with dwindling resources, it is very clear that the degree of change that is required within food and agriculture systems, and the pace with which that change needs to be delivered, compels us to adopt new ways of doing things. From an industry perspective this agricultural revolution is being determined not only by these global environmental factors, but also by the demands of Caribbean consumers. Consumers rightly expect us to deliver quality food produced to increasingly high social, environmental and ethical standards. Leading food retailers, including our own, understand this issue well. After all, for most of the Caribbean population, retailers are the public face of the food chain. It is this unique position in the supply chain – as the interface between the industry and public – which underlines the key role retailers have to play in connecting researchers, farmers, producers and manufacturers to the markets they serve.

I am delighted to represent the Anton the Kom University of Suriname and to co-chair this 51st CFCS Annual Meeting tasked with shaping this Agri-Tech Food Security Theme. The underlying goal is sustainable intensification of our agricultural sector. This is not a term we should be scared of. It is simply about getting better productivity and yields with reduced inputs and environmental impact. The Agro Industry has already shown this can be done by, for example, using GPS and precision farming techniques to ensure more targeted application of inputs. One of the challenges posed in this conference is how we translate existing research and scientific know-how so that we move the industry forward as a whole. Agricultural science and technology is rapidly becoming one of the world's fastest growing and exciting markets. It is driven by global changes: a rising population, rapid development of emerging economies with western lifestyle aspirations and growing geopolitical instability around shortages of land, water and energy. A technology revolution is also taking place. Breakthroughs in nutrition, genetics, informatics, satellite imaging, remote sensing, meteorology, precision farming and low impact agriculture mean agri-tech has huge potential for development. Supportive conditions include active and effective research, sustained community participation, state support and progressive policies, adequate investment and multi-stakeholder partnerships across scales and between sectors. Whereas these conditions are met, agriculture-led growth generates substantial improvements to human well-being and helps meet a number of human development goals, including gender empowerment, poverty alleviation and food security.

The agri-tech sector and food supply chain in the Caribbean ranges from large research and development intensive multinational companies to small innovative SMEs, major retailers and family farms. We need to increase the agricultural production in the Caribbean. This increase in agricultural production can be brought about by bringing additional area under cultivation, extension of irrigation facilities, the use of improved high-yielding variety of seeds, better techniques evolved through agricultural research, water management, and plant protection through judicious use of fertilizers, pesticides and cropping practices. We need to develop a strong and vibrant food-processing sector with a view to create increased job opportunities in rural areas, enable the farmers to reap benefit from modern technology, create surplus for exports and stimulating demand for processed food. To strengthen support for the agri-tech subdivision in the Caribbean for a more productive and competitive sector for the reduction of food importation bills, we need more competent professionals entering the sector and train the existing labor force in clearer, more prioritized investment in skills; better co-ordination and proliferation of best practice and knowledge transfer; and a stable regulatory environment.

I am particularly concerned with the human development aspect in de Agri-tech sector. We need a (Caribbean) governing body to support investment in skills (sector skills council for agriculture) and a roadmap for action to:

- improve clarity and communication of available training and advice
- establish and communicate the future skills needs for the sector
- participate in the design and investment in courses and vocational training
- identify opportunities to support skills development and knowledge transfer
- Development programmes for small and marginal farmers.

As we look towards the future, we need to refine a long-term strategy that encourages the agrifood sector to exploit emerging opportunities, whilst minimizing red tape and burdensome costs.

Our mission is **to ensure the sufficient supply of safe and sustainably produced food at a quality which our consumers expect – despite the uncertainties which farmers face, such as weather, animal disease or market prices.**

This mission of delivering food security for people at home and abroad is more relevant now than ever, with rapidly increasing global population growth, evolving consumer patterns, as well as diminishing natural resources, and political instability in certain key regions. Let us therefore resolve to work together to create a coherent and ambitious vision, which reflects the best of Caribbean's agriculture:

- Let us explore the possibilities of new markets for our high-quality Caribbean product;
- Let us enhance competitiveness and productivity by giving farmers the right type of training and support, allowing them to innovate and create jobs;
- Let us inject new vitality into rural areas by increasing the diversity of opportunities available to those who live and work there;

- Let us lay the foundation for the renewal of agriculture by encouraging young farmers to get involved.
- Let us develop a knowledge-based response to the Caribbean's climate change, environmental and broader sustainability challenges.

In the coming days several oral presentation will be presented and posters will be displayed and we will discuss issues with in-depth deliberations shaping the future of the Caribbean Agro sector.

Distinguished guests, ladies and gentlemen, today's multifaceted food industry and fast changing world calls for a close partnership between countries. Globalization presents many challenges to our Region and as such we should cooperate with the aim of achieving mutual benefits. I hope this conference will highlight possible avenues for cooperation between countries and also come up with beneficial, cutting-edge resolutions, which can positively impact the agribusiness of member countries.

In closing, I wish to express my gratitude to each and all of you for your full cooperation and contribution to the 51st Annual CFCS Meeting. I take this opportunity to thank the Local Organizing Committee for organizing this meeting and for providing the necessary funding and for their diligence. The various sponsors for lunches and dinners are also thanked for their kind hospitality. I wish all the participants a very fruitful and productive meeting/conference and wish you all a good time in our country.

Thank you very much for your attention.

Inauguration and Remarks
by
Dr. Wilfredo Colón, Chair and CEO, CFCS

Good morning Excellency, ladies and gentlemen,

It is an honor and privilege to be here today, to officially inaugurate our 51st Annual Meeting of the CFCS.

First of all, I want to recognize some very important individuals who have worked diligently and energetically to make this meeting possible.

1. Prof. Henry Ori, Member of the AdeKUS Board of Directors and President of the CFCS for 2014 – 2015,
2. the Hon. Suresh Algoe, Minister of Agriculture, Animal Husbandry and Fisheries of Suriname and Joint President of the CFCS for 2014 – 2015,
3. Dr. ir. Sidin Ryan, Chairman of the Board AdeKUS,
4. Dr. Lydia Ori, Director of the Agricultural Production Department of AdeKUS and Chairwoman of the Local Organizing Committee (LOC),
5. Mrs. Ranoe Mangal-Jhari, Programme Manager, Program Support Unit, VLIR-AdeKUS and Vice-Chairwoman of the LOC,
6. Mr. Djoemadi (Didi) Kasanmoesdiran, Ministry of Agriculture and member of LOC,
7. Dr. Abimbola Abiola, Representative of the Inter-American Institute for Cooperation on Agriculture in Suriname and member of LOC,
8. Dr. Inez Demon, Director of the Center for Agricultural Research (CELOS - Agricultural Experiment Station, AdeKUS) and member of LOC,
9. Ir. Winston Ramataursing, Development Economist, PROPLAN and member of LOC,
10. Mr. Robert Tjien Fooh, AdeKUS.

I also want to recognize the colleagues at the head table:

1. Dr.Lystra Fletcher-Paul, Food and Agriculture Organization (FAO) Country representative,
2. Mr. Barton Clarke, the newly appointed Executive Director of the Caribbean Agricultural and Research Development Institute, CARDI,
3. Dr. Raul Machiavelli, Dean, College of Agriculture, University of Puerto Rico,
4. Prof. Clement Sankat, Pro Vice Chancellor and Campus Principal of University of West Indies (UWI) and
5. Dr. J.R. Deep Ford, Food and Agriculture Organization (FAO), Subregional Coordinator for the Caribbean, our main keynote speaker.

In addition I want to present and recognize the Members of the Board of the CFCS. I want to start with:

1. Vice Chairman: Dr. Harry Ozier-La Fontaine, INRA, Guadeloupe,
2. Secretary: Mr. Jean-Louis Diman, INRA, Guadeloupe,
3. Treasurer: Dr. Alberto J. Beale, University of Puerto Rico,
4. President 2015: Prof. Henry Ori (Member of the Board of AdeKus) and Co-President Hon. Suresh Algoe (Minister of Agriculture).

Our Regional Representatives from:

1. English Caribbean, Mr. Kwame García, University of the Virgin Islands, Dr. Richard Harrison, Jamaica, and Mr. Barton Clarke, CARDI, Trinidad and Tobago.
2. Spanish Caribbean, Mr. Rafael Pérez Duvergé, IDIAF, Dominican Republic and Mr. Jerry Dupuy, Private Sector, Dominican Republic.
3. French Caribbean, Dr. Isabelle Jean Baptiste, AMADEPA, Martinique, Mr. Marceau Farant, INRA, Guadeloupe, and Dr. Harry Ozier-La Fontaine, INRA, Guadeloupe,
4. Dutch region, Dr. Lydia Ori, AdeKUS, Suriname,
5. President of our Advisory Committee, Dr. Edward Evans, IFAS, University of Florida, USA.

Ladies and gentlemen by the power invested in me as the Chairman of the Board and Chief Operating Officer of the Caribbean Food Crops Society, I officially declare and inaugurate our 51st Annual Meeting. Please let's give ourselves a big round of applause to convene our most sincere appreciation for our noble and generous dedication to ensure the success of this meeting.

Now please bear with me for the following remarks. The 68th United Nations General Assembly declared 2015 as the International Year of Soils. As agricultural scientists we are extremely aware that we need to secure and increase the biodiversity of our soils in order to maintain their sustainability and productivity to insure food security for our planet. Biodiversity is expressed in the rich mixture of organisms and life forms that make the soil their home. This richness translates to the soils resilience to withstand those factors associated with climate change.

Today we are meeting in a very unique country. Suriname is considered one of the most diverse countries on the planet. If we step out of these doors and listen to its citizen, we will hear over 10 languages. If we turn on the radio we will listen to a diversity of tunes. If we seek spiritual guidance, we can choose from all the major religions and indigenous faiths.

The CFCS also reflects with its actions this conviction to biodiversity and human diversity. For our 50 years we have strived to be inclusive, and tear down the cultural and political forces that separate us in the Caribbean and to create a professional platform in which we can express and share our research results to a wider audience. In this time frame the CFCS had meet in Suriname on two occasions, in 1967 and 1978. In 1967 we celebrated the 5th annual meeting with 55 representatives from 17 countries. The 15th annual meeting held in1978 coincided with the 75th Anniversary of the Suriname Agricultural Experiment Station.

Now after almost four decades we are back in Suriname. This meeting was long overdue. During this time frame, we have maintained our mission to be an independent professional organization with interdisciplinary orientation and membership, which fosters communication between persons capable of contributing to the development of science, technology, and production of food crops and animals in the countries of the Caribbean Basin. We are all a testament to the efforts of those who came before us and carried this torch of scientific and cultural fellowship which we will enjoy during this week.

Thank you very much for your attendance and I wish you a very fruitful and pleasurable meeting.

Remarks
by
Professor Clement Sankat, Campus Principal,
The University of the West Indies, Trinidad and Tobago

Salutations
Thank You Chair, Dr. Lydia Ori
Hon. Soeresh Algoe, Minister of Agriculture, Anima Husbandry and Fisheries
Dr. Ryan Sidin, President of the Board of Anton de Kom University of Suriname
Dr. Wilfredo Colón, President of CFCS
Mr. Gerard Van Ouden of the EU-ACP Edulink Programme in Brussels
Prof. Dr. Henry Ori,- President of CFCS 2015 Suriname
Dr. Lystra Fletcher-Paul, FAO country representative
Dr. Barton Clarke, Executive Director of CARDI
Dr. Abimbola Abiola, IICA Representative in Suriname
Prof. Dr. Tom Vanwing, VUB, VLIRUOS representative
Dr. Hector Belle, CACHE Director
Other members and representatives of CFCS, Conference Sponsors
Conference participants, specially invited guests
Students of Agriculture
Farmers' Organizations
Colleagues of The UWI and other Universities
UWI Alumni
Distinguished Ladies and Gentlemen

Good morning!

It is indeed with great pleasure that I bring greetings to you all on behalf of The UWI St. Augustine Campus community and by extension the regional University of the West Indies on this special occasion – the Opening Ceremony of the 51st Caribbean Food Crops Society (CFCS) Annual Meeting!

I would like to begin by expressing my sincere thanks to the President of CFCS 2015, Professor Dr. Henry Ori and his team, together with the President of the Board of Anton de Kom University of Suriname, Dr. Ryan Sidin, and the Honourable Suresh Algoe, Minister of Agriculture, Animal Husbandry and Fisheries for inviting me, and in so doing, allowing The UWI to be a part of this annual conference! A conference which the Caribbean Food Crops Society has been hosting consistently for over 5 decades!

Congratulations to the CFCS!

Ladies and gentlemen, not only is Food indispensable to human life, but according to the World Bank, agriculture based growth is at least twice as effective in reducing poverty as GDP growth in other areas. Agriculture, food production and the business side of these elements should therefore be of utmost importance to all of us in the Caribbean if we are to treat with problems of our Caribbean States – high unemployment, high food import bills, debt, competitiveness etc. In this regard, I wish to commend the Caribbean Food Crops Society (CFCS) for staying the course to host these conferences throughout the years which has provided a unique forum for the examination of our policies, systems and practices, and our institutions in the Caribbean region and beyond. Let me also say that these meetings have not only provided a forum for sharing of new ideas that can help to strengthen the agricultural-food chain, and especially for our young researchers from various parts of the Region. This forum has also given them a chance to know other regional researchers, to network and to know more about our Regional Agriculture - its problems and possibilities.

As an Agricultural Engineer and researcher myself (and as many of you know), I have been a longstanding member of the Caribbean Food Crops Society (CFCS) for over 30 years and have attended many of their annual meetings - some very memorable such as in St. Croix (United States Virgin Islands), Puerto Rico and Antigua. These are memories that I truly cherish. Just two years ago in 2013, the 49th Annual Caribbean Food Crop Society (CFCS) Meeting, was combined with the 30thWest Indies Agricultural Economic Conference and the International Society for Horticultural Sciences (ISHS) Meeting, and this was hosted by The UWI, with the kind support of the Government of Trinidad and Tobago. Our regional University of the West Indies has always seen itself as a close partner in these efforts, especially as it relates to underscoring the importance of agriculture and food production to the countries of our Caribbean region, the world over and this through our renewed Faculty of Food and Agriculture and our Faculty of Engineering at The UWI St. Augustine Campus.

This year's overarching theme, "Food Safety, Innovation and Quality in Green Agriculture: The Way Forward to Food Security for the Caribbean" is extremely timely and relevant. It once again aptly pronounces the direction in which we in the Caribbean ought to be moving given the state of agriculture and food production in our region. I do believe that while it is important for us to focus on food security (that is, the availability of food for our people), we must not ignore:

1. The importance of Food Safety, Nutrition and Health
2. The ecological impact of our Agricultural/Food Production Systems and Sustainability;
3. The importance of utilizing technology and innovate on in food production processes and practices; and investing in R&D;
4. The socio-economic conditions of our countries of the region and the role of food and agriculture in building robust, balanced and prosperous, self-fulfilling societies.

These are all areas that I will speak about tomorrow, but notwithstanding, I want to emphasize the point that we must pay very close attention to not only how much food we produce, but how we produce this food, and the impacts of our food production practices on our environment. As we gather for the next few days to speak on Agriculture and Food, these are not issues that we must take for granted. We must learn from each other on past missteps and on new ideas, approaches and systems for food production and trade. We must remember the words of Winston Churchill who said, "Those who do not learn history are doomed to repeat it".

Ladies and gentlemen, developing a sustainable agricultural sector for the Caribbean region requires collaboration among all stakeholders – economists, agrologists, teachers, researchers, farmers, extension officers, consumers and public and private sector representatives. We must open our space in the Region for collaboration and team work, in agricultural trade, removing all barriers to regional trade for example, in the sharing of best agricultural/food/nutrition practices and in Research and Innovation. We must work together if we are to build sustainability and resilience in our food/agri-product systems.

In closing, I say congratulations to the organizers; I recognize the hard work of Prof. Ori and his team; the support of the Government of Suriname; and to all participants who made the effort to be here. On a personal note, it is great to be in Suriname, a land of my shared ancestry! A land which when in my early youth in the Corantyne, I often opened my eyes and looked across the brown, wide Corantyne River. I asked myself many times, what is on the other side of this river and in this densely forested, green land? Well today, 50 years and more, I am still discovering this lovely, progressive land of many tongues and cultures!

Thank you for inviting the Regional University of the West Indies to CFCS 2015, and Suriname - best wishes for a successful conference!

Message
by
Dr. Ir. Sidin, President of the Board of
the Anton de Kom Universiteit van Suriname

Honourable Minister of Agriculture, Animal Husbandry and Fisheries,

Distinguished Guests, Ladies and gentlemen

Let me begin, by welcoming you all to Suriname for the 51st Annual Meeting of the Caribbean Food Crops Society, CFCS. We are delighted to have you here to participate and share knowledge in this meeting and its corollary conference on food safety. This year's theme is "Food Safety, Innovation and Quality in Green Agriculture", The Way Forward to Food Security for the Caribbean" and I am proud to say that the local organizing committee has put together effective programs which offer a wide variety of activities to address the problem at hand.

It is no accident that food security is one of Suriname's priorities in development policies in the Agribusiness. The number of people without access to sufficient, nutritious food is unacceptably high. High and unstable food prices are root causes of almost all the sociopolitical crises in the world today. Think of Tunisia, Algeria, Yemen and African countries as Egypt and, little closer to home, Haiti. Food security is crucial in achieving the hunger reduction targets of the World Food Summit and Millennium Development Goal # One.

With all the knowledge and expertise assembled at our Anton de Kom University and databases available at science institutions in countries of the Caribbean basin, we can make a difference.

Let me give you my definition of food security. Food security is about production, accessibility and nutritional value. And about ensuring that those who do not produce food have the income they need to buy it. This requires action on all fronts. Let me give a quick overview.

Farmers' response to increasing demand and higher prices has been excellent in recent years. And of course Mother Nature has helped a lot, resulting in bumper crops and full silos. Unfortunately, ever-growing demand combined with somewhat disappointing harvests – remember the droughts and fires, the floods and the relatively low production in the Southern Hemisphere – is now causing even higher food prices. Moreover, unstable and unpredictable prices at national level are preventing farmers from consolidating their investments. In fact, the insufficient buying power of farmers producing for a local market in developing countries is preventing them from investing at all.

In other words, there is work to be done. As I just said, our most important tool for progress in countries in the Caribbean is economic growth. Only growth can help people help themselves. But conditions in our countries are far from ideal for private sector development. The private sector plays a crucial role in economic growth and food security. In horticulture, dairy farming or livestock rearing, we need to build strong public-private-partnerships. But of course, local businesses, farmers in particular, are even more important for economic growth and food security in Caribbean countries.

Caribbean countries in general, have a lot of farmers many of whom however, lack market information, banking services, credit facilities and insurance, on top of which fertilizers and quality seeds are in short supply. These are all factors crucial to the contribution of success of small farm operations in our region. A good farmer needs to be a good entrepreneur.

That is why we should be helping farmers become more businesslike, by providing;

- safety production nets and social security;
- market access and sustainable production chains;
- investment in inclusive finance and infrastructure;
- knowledge on innovation and quality and
- by sharing our knowledge about markets, organizational strategies, research and development.

We should work closely with the Ministry of Infrastructure and the Environment to achieve these goals, and – even more relevant for you – with the Ministry of Economic Affairs, Agriculture and Innovation. We need to come up with a plan to streamline the efforts of local, regional and international players in the field of food security.

Now back to you. Research institutions like the Anton de Kom University should seize the opportunity to liaise with other Universities in de Caribbean and offer solutions tailored to specific, real-life problems. Solutions devised by the countries themselves.

Ladies and gentlemen,

In his book "Common Wealth: Economics for a Crowded Planet", the well-known economist Jeffrey Sachs argues that there is more room for optimism. Firstly, because the world population is likely to stabilize in the last century. And secondly, because technical progress will probably be faster than in the past. But, says Sachs, this is no reason to sit back and relax. He wonders whether the world is organized enough and cooperative enough to meet the challenges it faces.

I agree with Sachs that there is room for improvement. So let's start working together today. We can feed the world in a sustainable way. Even with 9 billion people in 2050. Let's do it.

I wish you a fruitful conference and hope that visiting Suriname may inspire you.

Thank you for listening.

Speech
by
Hon. Soeresh Algoe, Minister of Agriculture, Animal Husbandry and Fisheries

Deputy Minister, Ambassadors
Honorable guest
Distinguished speakers
Ladies and Gentlemen,

Good Morning,

May I extend a special word of welcome to all of our guest from abroad and especially from the Caribbean and I wish you all an enjoyable stay in Suriname.

Ladies and Gentlemen,

I would like to start my speech with an observation that is at the core of the problems with Agricultural health and Food Safety and that is that producers break the rules on the use of pesticides and animal medicines. And I don't have to tell you what the consequences are on public health and export of agricultural produce. Scientific and technological advances are opening up new possibilities for farmers around the world (networked digital farm).

If everyone would follow the rules, and if we would all go for a greener agriculture life would be a lot easier but that is unfortunately not reality. Agricultural Health and Food safety are probably the most important conditions to guarantee food security for our countries and of course the entire region and the rest of the world. The only way to achieve this is when all parties (farmers, manufacturers, trade and consumer organizations) work together.

The free movement of safe and healthy food is an essential aspect of trading of food crops on export markets. It contributes significantly to the health and well-being of domestic as well as regional consumers. As a member country of WTO, FAO, WHO, OIE and the Codex Alimentarius and as a party to the conventions of the WTO/SPS, IPPC and OIE Suriname has committed itself to food safety. Achieving and ensuring food security for the total population of Suriname and ensuring agricultural health and food safety are the first 2 goals of the 7 strategic goals of our government's agriculture policy.

As from 2003 the Ministry of Agriculture, Animal Husbandry and Fisheries have taken a lot of measures to bring our food safety to international standards. We have to name some of them.

- Set up an Agricultural health and Food safety Unit,
- Set up a Trace back system
- Updated our pesticides law
- Establish by law a Fish Testing Institute
- And implemented Capacity building and training programs.

Ladies and Gentlemen

Agricultural Health and Food Safety are complex things to achieve and to maintain. For the development of norms, standards, rules and regulations on food safety the following aspects needs to be taken into consideration:

A Chain approach. All rules and regulations should apply to all links in the chain from primary production to consumption.

- Consumer's interest. High rate of transparency and openness, and assurance of public health is necessary to ensure consumer confidence.
- Role and Responsibilities of Public and Private sector. Each producer in the chain is fully responsible for the products they produce. The government establishes the necessary pre-condition, and provides for adequate control and enforcement mechanisms
- Science based. Measures should be based on scientific findings and international norms and standards. National procedures and regulation, and the legal system should also be taken into account. In companies, government and society, decisions must be made based on proven scientific solutions that can fulfill societal needs.
- Economic interest. Increase of agricultural produce for domestic consumption as for export to foreign markets is very important to increase the economic resilience of our Countries. If the products do not comply with the food safety, and agricultural and animal health requirements of the export markets, we will risk losing our market share and export revenues, and jobs in and linked to the agricultural sector.

Ladies and Gentlemen

Next to all other wonderful technical and interesting issues that will be presented here by the distinguished speakers I would like to ask your attention for what can be considered also important in terms of implementation of food safety strategies and policies and these are:

- Communication. We need to develop a communication plan. What are the messages, who are the target groups, How, when do we communicate, what medium and technique is used. Promoting open exchange is a way of growing knowledge.
- Develop public awareness. Training programs in Food Safety, Consumers awareness programs, research and survey
- Capacity and Institutional building. Certification programs, Quality management, survey, monitoring systems, ICT, Laboratories, Setting up of necessary institutes, Updating laws.

Ladies and Gentlemen,

Complying with the international norms and standards of Food Safety is top priority for Suriname. If everything will go as planned before the end of next year 2016 all of our laboratories will be operational under an independent Agricultural health and Food Safety Institute which will inspect and monitor the whole production chain of food from cultivation to processing to ensure that the food is safe for the public health. Helping growers produce high-quality, safe and healthy food and thereby contributing to a better life.

At last I would like to mention also that Suriname has provided facilities such as housing for the Caribbean Agricultural Health and Food Safety Agency (CAHFSA).

Honorable guests, Ladies and gentlemen I would like to wish you all, a fruitful and successful annual meeting.

Thank You.

Proceedings of the Caribbean Food Crops Society. 51:1-9. 2015

THE WAY FORWARD TO FOOD AND NUTRITION SECURITY (FNS) - CARIBBEAN

J. R. Deep Ford, Food and Agriculture Organization (FAO), Subregional Coordinator for the Caribbean

MEETING FNS NEEDS: PAST AND PRESENT

In explaining the past and present of FNS three aspects are considered: 1) Domestic food production; 2) Agricultural exports and 3) Tourism. (National production base lost - for the selected products with the exception of rice and poultry meat the per capita domestic production of these products have declined. Average CARICOM citizen is spending about ten times more on imported fruits and vegetables as they did on 1970. Import value over population graphics show that products we hardly imported before are now imported at a regular basis, see figures 1 and 2.

Per Capita Production in *CARICOM* – *Selected Products*

Domestic Production per capita (Int. $)	1970	1995	2005	2009	2012
Goat meat	1.5	0.8	1.2	1.1	1.0
Sheep Meat	0.4	0.3	0.3	0.4	0.3
Pigmeat	6.5	4.3	5.2	5.0	4.9
Bovine Meat	10.6	10.0	10.5	9.4	9.5
Poultry Meat	6.7	12.0	20.6	20.8	21.1
Rice	13.0	17.7	12.4	15.6	16.8
Fruit + Vegetables	171.2	129.4	105.6	112.0	110.3

Figure 1

Per capita expenditure on imports in CARICOM – Selected Products

COMMODITY ($Int.)	1970	1995	2005	2009	2012
Sheep and Goat Meat	0.3	1.5	2.1	2.7	3.2
Bovine and Pig Meat	4.2	6.7	10.3	11.3	14.7
Corn + Wheat+ Flour	4.7	14.4	13.3	19.9	22.0
Poultry Meat	0.7	5.6	7.8	10.0	16.0
Rice	1.7	9.1	10.4	16.7	19.8
Fruit + Vegetables	3.4	12.4	23.4	27.7	32.9

Figure 2

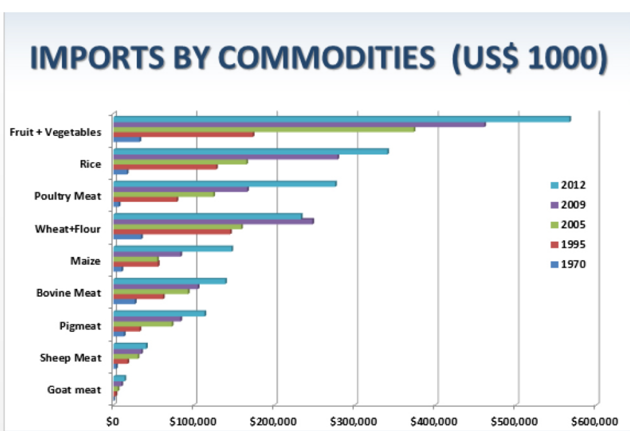


Figure 3

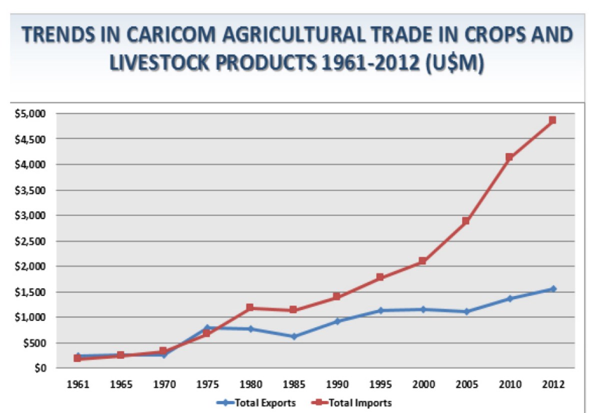


Figure 4

Figures 3 and 4 show strengthening evidence of increase in imports and the outflow of cash for Caribbean comunity

Export pillars of support for access to food have weakened, see figures 5 and 6 a clear decline in some countries for sugar and bananas export. We have recognized this and for decades called for diversification – efforts have been made but few successes, one of the main reasons mentioned by Dr.Ford is the failure to implement public policy in a manner that results in transformational change.

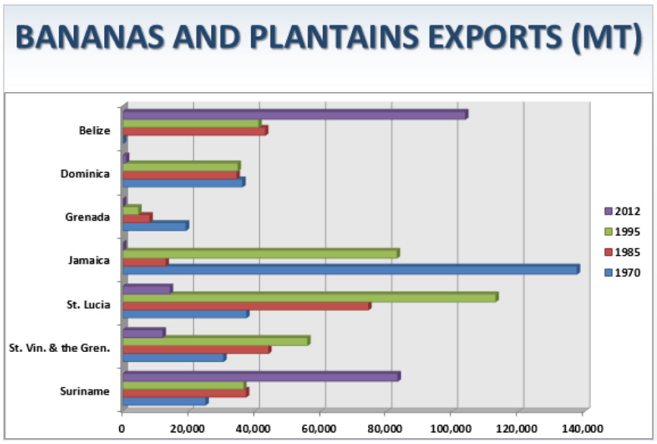


Figure 5

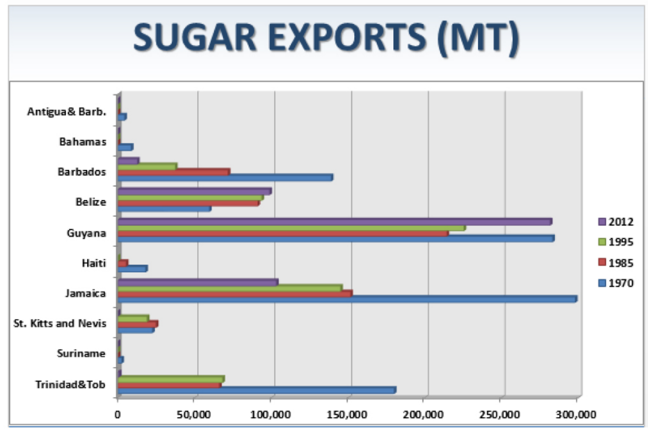


Figure 6

Whilst rice exports decline there is a noticed increase in citrus and bananas, which again highlights the importance of diversification, see table below the increase of citrus and bananas export from 1990 to 2000. Tourism is also an avenue of income, see fig 7. However A clear trend is portrait that the import of goods exceeds the export with also a future projection that this trend will still exist, given the level of crisis playing a major or minor role, see figures 8 and 9.

Belize				
% Contribution Agricultural Value Added				
	1971-1980	**1981-1990**	**1990-2000**	**2000-2012**
Sugar	**89**	**68**	**46**	**27**
Citrus	**7**	**18**	**21**	**24**
Bananas	**3**	**12**	**25**	**23**

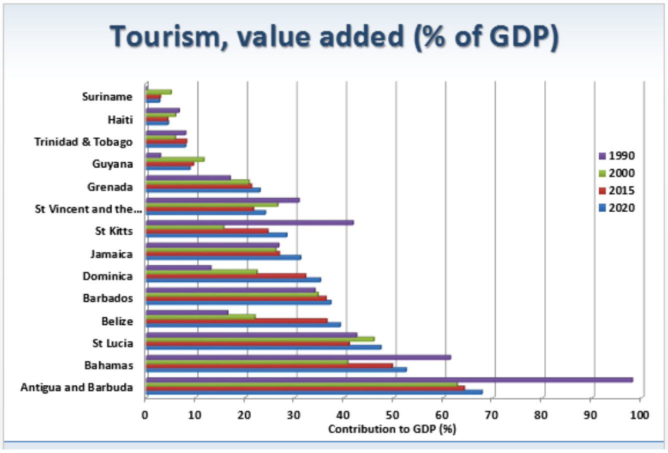


Figure 7

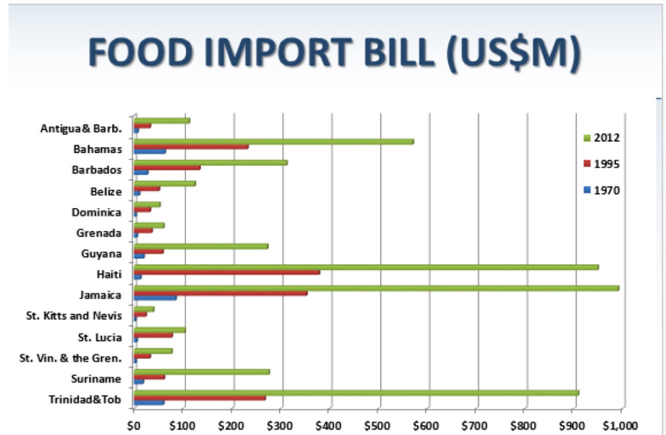


Figure 8

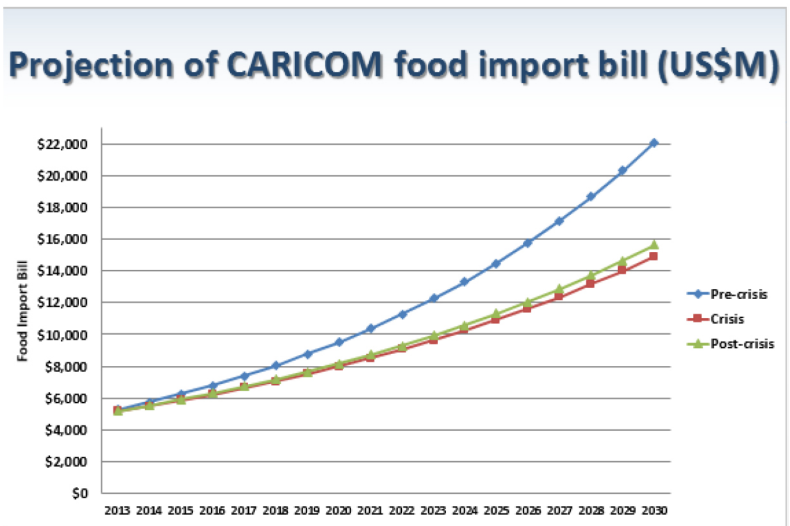


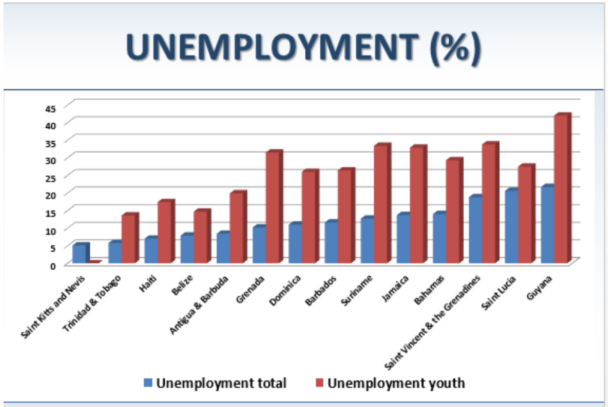
Figure 9

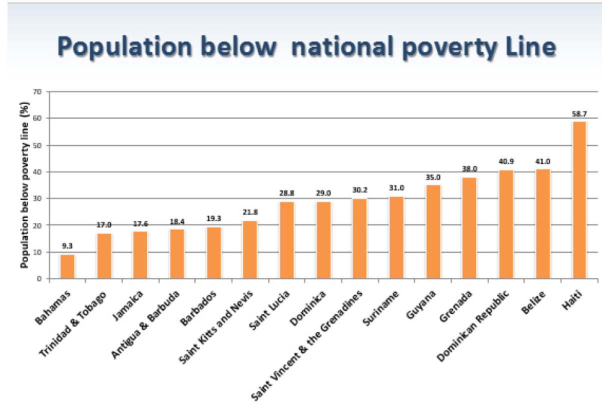
Food Security Challenges – Now and in the Future:

The main focus points in FNS are: Accessibility; Utilization; Availability and Stability.

Accessibility:

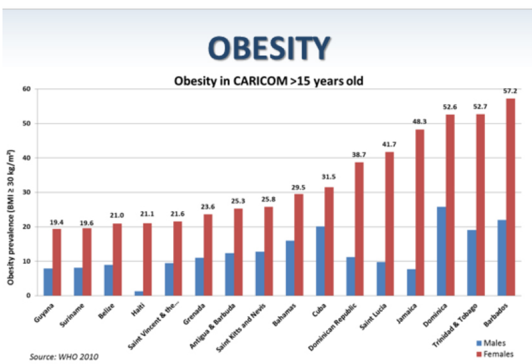
What are the employment rates? We see a very high unemployment ration in youth especially in Guyana. And a high poverty number for Haiti. Unemployment and poverty can damage a population's right to FNS.

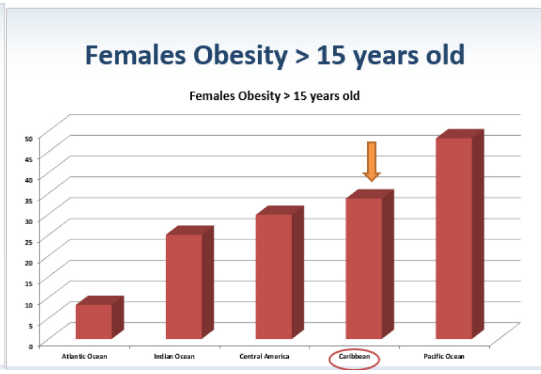




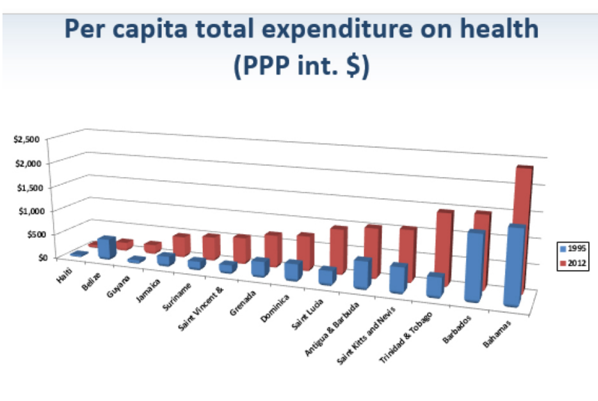
Utilization:

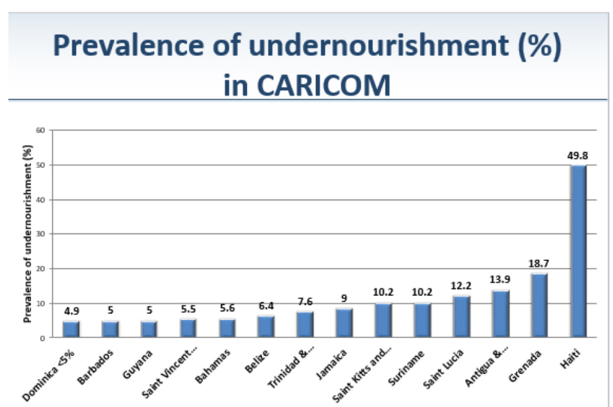
The foods that are imported can cause serious health risks in the population, see figures below, which indicate an increase in obesity level for women from 15 years and above.





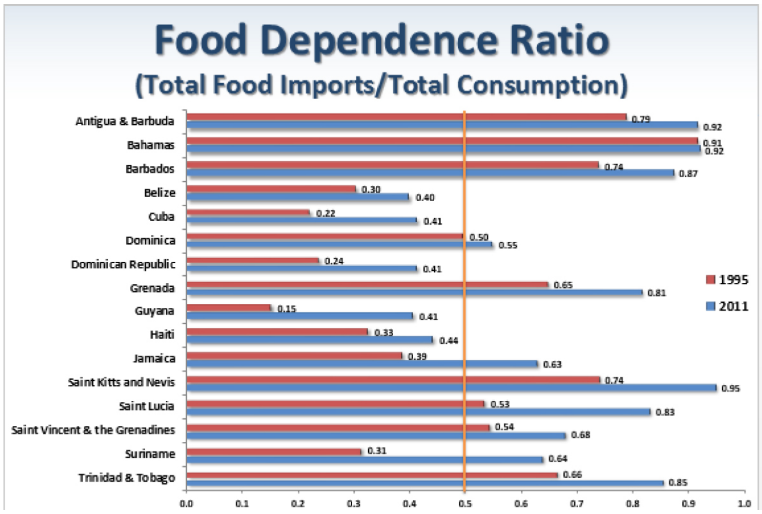
What is the health benefit of imported foods? Figures below the substantial difference through the years and the impact related to low quality FNS.

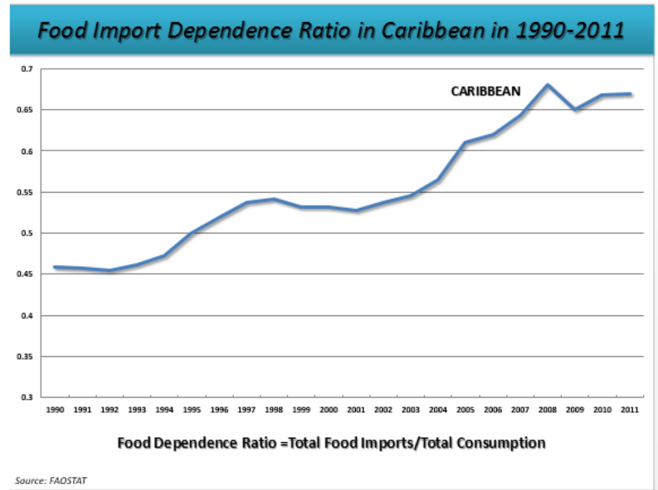




Availability:

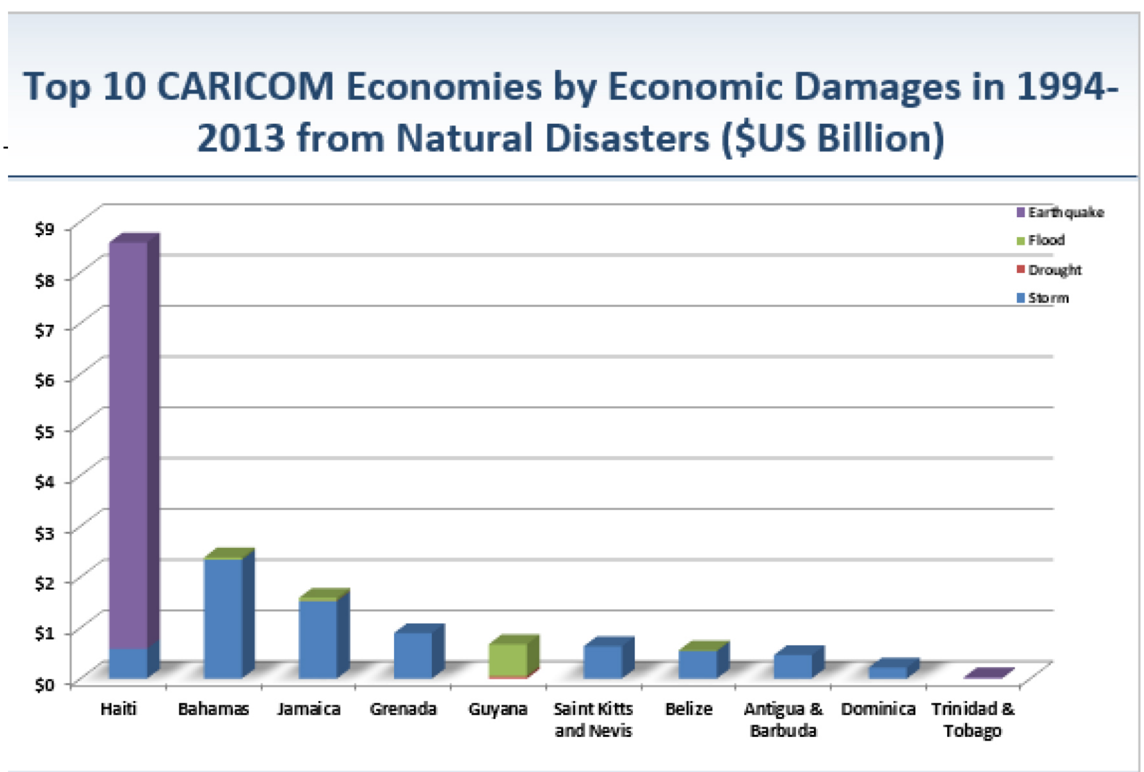
Through a monitored span of ±two decades the Caribbean community dependence on imported food has increased, a clear ration of double increase can be observed for the countries Cuba, Guyana and Suriname.





Stability:

Natural disaster can cause major impact in FNS for the Caricom. When a country does not produce but depends on import, economic damage can lead to impacts in quality and quantity of food. This situation occurs when populations have been effected natural disasters.



Challenges to be addressed in the Caribbean region:

- Food import dependence and agricultural exports
- Unemployment and poverty
- Obesity and NCD's
- Disasters risk and climate change

Key Elements of Public Policy for Ensuring Food and Nutrition Security are:

- Global, Regional and National Mandates
- Translating Mandates/Policies into Practice

Mandates that can support the FNS policy issues:

- Global Public Policy on Food Security
- 1996 – World Food Summit –Food Security Definition, 2015 Goal and Pillars (UNFAO, November 1995, Rome)
- 2000: UN Millenium Declaration Development Goals (8) – Goal 1: Eradicate extreme poverty and hunger
- 2012: United Nations Zero Hunger Challenge.
- CARICOM Agricultural Policy – Regional Level

The 4 objectives mentioned and explained earlier of the Caricom Food Security and Nutrition Policy:

- Food availability – production, commercialization, safety and quality.
- Food utilization/ nutritional adequacy – nutrition status and NCDs.
- Food access – vulnerable, affordable.
- Stability of food supply – natural and socioeconomic crises.

5 Pillars of Caribbean Community Agricultural Policy:

1. Food and Nutrition Security.
2. Production (trade) value chains
3. Sustainable development of natural resources.
4. Rural modernization and youth programmes
5. Agricultural knowledge and information system

Strategic Plan for Caribbean Community 2015-2019: Repositioning CARICOM

Agriculture defined as one of the Key Economic Growth Drivers to enable food and nutrition security:

- Establishing a system of regional indicators for Agriculture targeted at reducing the food import bill within specified time frames. Select commodities based on their potential competitiveness.

- Advancing initiatives for exports through attracting investment in small and large scale agrifood initiatives, while encouraging entrepreneurship among youth, women and small farmers (linked to building Social Resilience)
- Developing a fully integrated and harmonized Regional Agricultural Health and Food Safety System

Translating the Mandates/Policies into Practice across diverse CARICOM countries in FNS. The key Food and Nutrition Security Public Policy Action areas are:

1. Food/Agriculture Production and Value added – to address availability and food import bill
2. Consumption, Nutrition and Health Policy - to address food utilization, obesity and NCDs
3. Markets and Trade Policy – to address accessibility and food import bill
4. Land Use, Resilience and Sustainability Policy – to address stability and other risks
5. Governance Policy – to address institutional development and inclusion

Ad.1. Food/Agriculture Production and Value added - incentives to address domestic product availability:

- Ag. Revitalization - Value Chains and Family Farming (cassava, small ruminants, aquaculture)
- Technology Development/Adoption (Productivity Increases, Scaling Up)
- Entrepreneurship and Enterprise Development
- Praedial Larceny

Ad.2. Consumption, Nutrition and Health Policy - incentives to address food utilization, obesity and NCDs

- Regional and National Food and Nutrition Strategies – Actions plan implementation
- Zero Hunger Challenge Initiatives –Social Protection
- School Feeding Programs and Food Based Dietary Guidelines
- Cross sectoral networks – Healthy Caribbean Coalition

Ad.3. Markets and Trade Policy – incentives to address accessibility and food import bill

- Public and Private Sector Investment and Trade (Local Food Safety and Standards, intraregional trade)
- Public Purchasing Policy (local product purchases, food losses)
- Linking farmers to markets (organizations and contracts)
- Transportation and cross border issues (shipping and facilitation regulations)

Ad.4.Land Use, Resilience and Sustainability Policy – to address stability and other risks

- Land Management (Zoning, Idle lands, Access)
- Sustainable land and water management (rain water harvesting, efficient water use technologies, land degradation assessments)
- Climate change adaptation and DRM (drought resistant crops, improved damage and needs assessments)

Ad.5. Governance Policy – to address institutional development and inclusion

- National Level FNS Parliamentary Fronts
- National Level FNS TMACs
- National level Public/Private Sector Commodity Groups
- Regional Level Commodity Focused Working Groups

Importance of Governance, reflected in quotes:

"Good Governance is perhaps the single most important factor in eradicating poverty and promoting development" Kofi Annan, UN Secretary General, HDR, 2002

"We are going to create conditions in which all people in our country can eat decently three times a day, every day, without needing gifts from anyone. Brazil cannot continue living with such inequality. We must defeat hunger, poverty and social exclusion." President Luiz Inacio Lula da Silva, Inaugural address, January 1, 2003.

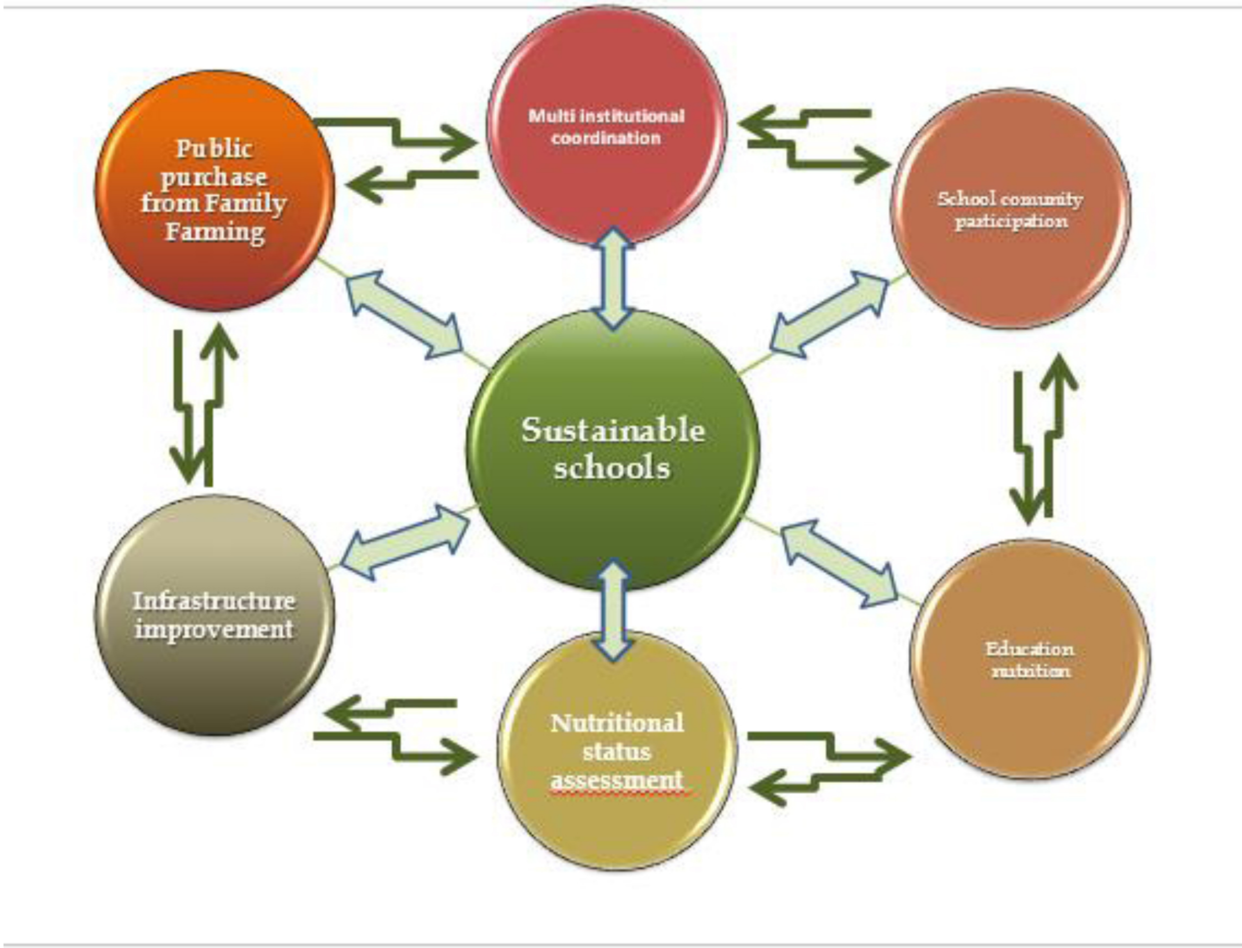
Ensuring our Future Food Security:

We need adequate public policy incentives that:

- Revitalize our food and agricultural sectors
- Promote nutritious and healthy food choices
- Facilitate local and regional market access
- Assist adoption of sustainable resource use practices
- Enable establishment of effective governance systems

% of National Budget to Agriculture

	Bahamas	Jamaica	Guyana	Suriname	St. Lucia	St. Vincent & Grenadines	Trinidad & Tobago
2002	..	..	..	2.26	..	5.8	1.52
2003	..	0.49	..	2.1	8.1	5.9	1.89
2004	1.24	0.65	..	3.3	5.3	5.3	1.82
2005	1.37	0.51	3.5	3.01	4.8	3.8	1.46
2006	0.87	0.71	4.3	2.99	3.6	3.2	1.24
2007	0.91	0.99	5.2	2.05	3.0	3.2	1.46
2008	1.08	1.21	3.4	3.22	4.6	4.2	1.29
2009	1.00	1.35	6.8	1.69	5.3	4	1.52
2010	0.75	1.29	5.7	1.35	4.7	2.7	1.32
2011	0.69	1.12	5.6	1.69	3.9	4	1.33
2012	0.85	1.30	7.3	2.88	2.7	3.5	1.33
2013	**0.87**	**1.13**	**5.3**	**2.83**	**2.7**	**4.3**	**1.09**
Agric. Value added (% of GDP)	**2%**	**7%**	**21%**	**10%**	**3%**	**6%**	**1%**


Multi institutional coordination
Public purchase from Family Farming
School comunity participation
Sustainable schools
Infrastructure improvement
Education nutrition
Nutritional status assessment

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FOOD SAFETY AND FOOD SECURITY ISSUES IN THE CARIBBEAN

L. Simeon Collins, CEO, Caribbean Agricultural Health and Food Safety Agency (CAHFSA)

Introduction

Food safety is an assurance that food will not cause harm to the consumer when it is prepared and/or eaten according to its intended use. Food security may be defined as the availability of food and the ability to acquire it.

Food safety issues

First foremost is food borne illnesses. Food borne illness is an illness caused by the consumption of contaminated foods. Over the past 20 years there has been an increase in reports of food borne illnesses worldwide including the Caribbean. Factors giving rise to increase in food borne illness: improved surveillance programmes; increasing number of elderly persons in the population; major deficiencies in personal hygiene practices (people do not wash their hands properly); increase in food preparation outside the home; changes in food preparation techniques; changes in microbiology. Changes in microbiology indicate the presence of: a) More virulent strains: *Salmonella enteritidis*: can now incorporate into uncracked "sterile" eggs; (b) Greater ability to grow at low temperatures such as *Y. enterocolitica*; *L. monocytogenes*

Examples of costs related in some cases

In the USA: 76 million cases of food borne illnesses each year; 324,000 hospitalizations; over more than 5,000 needless deaths and economic losses between US $7.7 - $23 billion/ year in USA. In the UK: over 5 million cases of FBI each year and thousands hospitalized. In the Caribbean 1990's and late 2005 there were very few documented outbreaks of food borne illnesses. We did not have a very organized monitoring and surveillance programs for FBI. In the Caribbean: 1997 reported 3 major tourist outbreaks in Jamaica; 1998 reported a similar situation in Barbados; in 2000 multiple tourist incidents in Jamaica. The cause for foodborne illnesses major serotypes are *Salmonella typhimurium* & *S. enteritidis*. Food poisoning at St. Ann's Mental Hospital, T&T. Morbidity - >300; Mortality-11. Suspect-Egg Nog (1992). Right now the situation has changed and as monitoring programs are becoming better, there are hunderds of FBI reports in the Caribbean annually. Major microorganisms that cause food borne illnesses: E. Coli; Faecal *Streptoccus; Salmonella; Clostriduim Botulinum*; *Staphyloccus aureaus; Shigella*; The vibrio spp.; *Hepatitis A; Listeria monocytogens*; *Clostriduim perfringens*. The overuse of either naturally occurring chemicals, intentionally added chemicals or unintentionally added chemicals is also identified as a food safety issue.

Examples of naturally occurring chemicals in food: Histamine: can be found in scombroid fish such as tuna, mackeral, bonita, etc. These fish contain high concentration of the amino acid histidine in their muscle tissues. Histamine is produced when this amino acid is decarboxylated by bacteria in the fish guts. It causes scrombroid food poisoning or histamine food poisoning. Symptoms include headache, nausea, dizziness, rapid pulse bit, flushing of the face. Onset a few minutes to several hours after eating.

Aflatoxin: This toxin is produced by the mold aspergillus flavus. Can be found in corn, peanuts, etc. This toxin can cause liver cancer if consumed in low doses over a long period of time (permissible limit 20 ppb).

Manioc (cassava): contain a chemical that breaks down into hydrogen cyanide in the stomach. It would be fatal if cooked and eaten. However, preparation procedures have been developed to make it safe for consumption by washing and extracting. In the Caribbean, two types of Cassava are grown, namely the bitter and the sweet Cassava. Both types of Cassava are acceptable to consumers but we mainly consume the sweet Cassava. Sweet Cassava root has low levels of cyanide (about 20 mg/kg) and it can be peeled and boiled like conventional tubers such as Yams and Potatoes. While the bitter cassava is considered edible, the toxin (cyanide) must be extracted. It contains about 50 times as much cyanide as the sweet cassava (1 g/kg).

Examples of intentionally added chemicals, which are mainly food additives: Preservatives (e.g. nitrites and sulphiting agents, benzoic acid); Color additives;

Nitrites has been used for centuries in curing meats. When added to meats at around 150-200 ppm, nitrites causes the natural red color to be fixed during curing to a pink color. This is what occurs in the manufacture of hams, sausage, hot dogs, salami, etc. Nitrite also helped develop the cured meat flavor. In the late 1960s it became evident that nitrites can react with certain types of amine compounds to form nitroamine which was found to cause liver cancer. In 1975, the FDA lowered the limits of nitrites in most products;

Sulphites are used to prevent discoloration in dried fruits and fresh-cut potatoes and to prevent discoloration and bacterial growth in wines, however, they can provoke allergic reactions. A typical reaction is difficulty in breathing within minutes of consuming sulphites. This occurs mainly among asthmatics;

Violet No.1: - was used until the Spring of 1973 for stamping the USDA inspection grades of meat onto beef carcasses. Some Japanese studies published at the time showed that Violet No. 1 Fed at 5% of the diet was carcinogenic; The FDA then banned it.

FD & C RED No. 2 was used in the American food supply until January 1975. It was the basic coloring agent used in lipsticks, candy, some foods and beverages. Red No. 2 was also used to color canned pet foods. In 1970 the Russians published a study questioning the safety of Red No. 2. The study showed early deaths and cancer in rats. It must be pointed out that they were not using FD&C Certified Red No. 2 but a more crude form (Amaranth) that contained some impurities. In studies carried out by the FDA, it was found that there was a 5% chance that RED No.2 at 3% in the diet was a chemical carcinogen. The FDA therefore delisted this color from the official color list.

Unintentionally or incidentally added chemicals: Agricultural chemicals (e.g. pesticides, fungicides, herbicides, fertilizers, antibiotics and growth hormones); Plant chemicals (e.g. lubricants, cleaning compounds, sanitizers, paints.

Food safety concern: Antimicrobial resistance is the ability of the bacteria or other organisms to survive the effects of antibiotics. Why a concern? Because the ability of bacteria to survive some commonly used antibiotics is increasing. This is because these common antibiotics are also used to treat serious infections found in livestock; Because of the extensive use of antibiotics in livestock, the bacteria present in a lot of food-producing animals have become resistant to antibiotics; When the meat of these animals are eaten, these bacteria is transferred to the human body as bacteria that can cause illnesses.

AMR and FOOD SAFETY

It is important that there should not be any misuse or overuse of antibiotics, so that the efficiency of the antibiotics is preserved for as long as possible.

Food security: Genetically manipulated foods are being proposed as the answer to foods security, with the following benefits:-resistant or herbicide resistant crops; yield fruits with delayed ripening characteristics; can reduce the use of water and agrochemicals in agriculture; plant varieties designed to produce increase yield. GMOs are organisms produced when genetic materials from one organism is inserted into another specie in order to introduce specific desired characteristics such as pest resistance, herbicide resistance or resistance to a particular disease. Genetic engineering promises remarkable advances in agriculture. This include:- increase in food security . Potential risks: Interaction of the GMOs with various ecosystems is not known. Potential areas of concern are: the possibility of adverse impact on non-target species (such as beneficial insects) and ecosystems; the potential dispersal of the GMO into the environment; the potential transfer of the inserted genetic materials (and related characteristics) to other native plants e.g. through cross pollination; possible effects on human health arising from the consumption of food containing or produced from GMOs

Survey in Europe: Do you think GM crops should be grown and eaten:- Yes 40.2% ; - Yes, but with labeling of GM products in food 6.2%; - Grow only for research and testing until we know more 13%; - No 40.6%.

USA Scientists: Any information against GMOs must be science-based. There is no scientific evidence that GM foods can affect the health of any one; Critics: We just do not have the scientific information yet.

Rio Declaration in 1992: Biotechnology is good; It may be important to prevent us from diseases and may be a solution to food security problems. Critics: But we are not certain. Precautionary Principle: If you are not sure be careful.

Caribbean: no firm position on the use of GMO's

Responsibility of FS: Farmers, traders, processors and importers are responsible for food safety; the Member State government authorities are responsible for control and enforcement of the legislation and standards.

Proposed solutions to food safety problems: USA: US Food safety modernization act, this act came to be on January 4, 2011. Under the new FSMA, all entities producing, handling, transporting, importing or distributing food have now to meet new food safety requirements to sell food in the USA.

EU: new food safety directives

Caribbean: possible solution: training farmers, food processors and others in GAP, HACCP, ISO 22 000. Formation of NAHFSA or steering committees of AHFS in each members state to coordinate enforcement and monitoring of standards and legislation; Feedback from the NAHFSA into CAHFSA to ensure that there is a regional approach to foods safety, plant health and animal health issues and to standardize our legislation and enforcement mechanisms. In conclusion we are all responsible for food safety and food security, we must all play our part.

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POLICIES TO ENHANCE FOOD SAFETY AND FOOD SECURITY IN SURINAME

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Abstract: The issues of food security, food safety, innovation in agriculture, and food production under conditions of climate change are highly interrelated and cannot be dealt with without a comprehensive and holistic approach. The trend of increasing food imports and decreasing output, within an unfriendly political environment bent on mining and unsustainable exploitation of natural resources, needs to be reversed. Resource use is low to sub-optimal. We are back in square one and should start with the basics. As there is no agricultural sector plan based on a comprehensive sector analysis, Suriname should first formulate an agricultural policy. The dynamics of agricultural production is changing constantly and climate change does have a negative effect on resources such as land and water. This implies a sector analysis every 5 year, in order to timely detect underperforming crops and products with respect to criteria such as resource use, capital output ratios, capital employment ratios, and contribution to food security and safety, economic value added, and value chain analysis, contribution to rural development and sustainable development, and benchmarking outcome. Based on earlier publications of author (Agricultural sector analysis, agricultural policy and agricultural development plan Suriname, vol 1-3, Kalloe Consultancy, September 2002; Restructuring Food Safety and Agricultural Health Authority, 13th November 2008; Agricultural Sector Analysis and Agricultural Development Policy to be published this year) guidelines are given of how to carry out such an analysis adequately, efficiently and effectively.

Keywords: food security, food safety, innovation, food production, agricultural policy

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IMPLEMENTING FOOD SAFETY PRACTICES IN VEGETABLE INDUSTRY

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Abstract: Food safety has become one of the important priorities to consumers, producers and handlers because an outbreak of foodborne illness can cause serious health problems even death, and the producers or handlers may face bankruptcy and litigation consequences. To prevent such risks the U.S. government has issued Good Agricultural Practices (GAPs) for fresh fruits and vegetables as a general guideline to minimize microbial food safety hazards. The development and implementation of the GAPs in various commodities of the vegetable industry require a comprehensive extension program for specific crops during growing, harvesting, transportation, packing, storage and handling of vegetable produce. The program is to train farm managers, on-site food safety coordinators, vegetable harvesters, shippers, packers, and processors to minimize any potential microbiological hazards associated with various aspects including land history, adjacent land use, water quality, worker hygiene, pest and fertilizer utilization, equipment sanitation, and transportation. The similar program will be valuable to the Caribbean region for food safety issues.

Keywords: Food safety, Good Agricultural Practices (GAPs), food safety hazards

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THE SMALE-SCALE FARMER IN VEGETABLE PRODUCTION IN SURINAME

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Abstract: Suriname is a thinly populated middle-income country, covering an area of 164,000 sq. km of which 80% is tropical rainforest. In Suriname, about 25% of the population is engaged in agricultural activities. Because of the availability of land, water resources, good climate conditions, and tradition and experience in vegetable production, Suriname has often been considered a potential "food basket" for the region. CARICOM countries, including Suriname, are also greatly dependent on agricultural imports to secure the food and nutritional needs of their populations. However, suitable land areas for agriculture are not optimally used to produce the needed vegetables. Almost all vegetable farmers are facing many challenges when producing food for local and international markets. To get more information about the current agricultural situation, a study of small vegetable farmers was conducted in Suriname. Using a survey study, 100 vegetable farmers were interviewed from vegetable growing areas. Results reveal that small farmers are aging and the information flow from the agricultural institution to the farmer is minimal. Preliminary data also show that access to quality agricultural inputs, capital, labor migration, insufficient knowledge of international standards, agricultural extension on IPM and ICM, and access to markets are obstacles that small scale vegetable farmers face. For small vegetable farmers to produce, more sustainably strategies need to be developed to: (1) improve research, extension and training capacity; (2) introduce labor saving agricultural techniques; (3) and establish cooperatives where capital can be build up for farm investments.

Key words: small farmer, vegetable farming, sustainable agriculture.

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AN EVALUATION OF FRESH MILK PRODUCED IN THE CARICOM; ASSURING QUALITY AND FOOD SECURITY

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Abstract: Caribbean (CARICOM) countries have traditionally hosted dairy industries that were pivotal to the supply of fresh produced milk to domestic markets. The main dairy producers in the CARICOM are Jamaica, Guyana, Barbados, Trinidad and Tobago and the Dominican Republic wherein, Trinidad and Tobago is the leading dairy producer. Currently, the Caribbean dairy industry is dominated by fresh milk production, with a range of artesian dairy by-products, including milk drinks and yoghurt, however local production of dairy products is often short of domestic demand for fresh milk and processed products. In an attempt to revitalise and evaluate the production of fresh milk, whilst maintaining affordability for consumers, innovative processing, packaging and distribution solutions linked to strong brand image, clear marketing and sector development strategies must coexist in harmony. Private and public sector interventions, agro-economic issues, improving pasture management and strengthening the genetic basis of the dairy all require an even ratio of domestic, trade, national and regional policy measures reinforced by technological innovation. This paper reviews and evaluates the various industry-led and public policy measures that are currently established. It emphasizes the local dairy industry as being essential to food and nutrition security for the region and suggests a way forward that ensures efficiency in high production, low operational costs, operational efficiency whilst addressing dwindling profits, shrinking markets, lack of clear incentives and rules whilst recommending guidelines for the management of fresh milk products and imports in the CARICOM region.

Keywords: Dairy industry, dairy technology, innovation.

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ADVANCING CARIBBEAN BIOSECURITY CAPACITY-BUILDING TO PROTECT THE ENVIRONMENT AND PROMOTE SUSTAINABLE FOOD PRODUCTION

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Abstract: Food security is a major concern and priority for Caribbean nations as well as the protection of sensitive natural recourses, which provides a renewable source of income by sustainable tourism initiatives. Both food and tourism industries have been affected by invasive species that disrupt local established food production systems and deteriorate the aesthetic and biological value of natural landscapes. The development of an integrative approach concerning invasive species and involving both food and tourism industries surely will be beneficial for the entire region. During the last decade several invasive species have been targets of research, educational training and development of diagnostic and management tools at our facilities. Some of these target pests and diseases were vector-transmitted viruses affecting major vegetable and fruit crops (cucurbits, tomato, pepper, papaya, citrus), viruses in soybeans, red palm mite (on coconut palms), *Harissia* cactus mealybug (on natural cactus populations in a dry forest), coffee berry borer in coffee, *Fusarium* in banana, phytoplasma in palms, *Helicoverpa armigera* in several crops, and *Brevipalpus* mites in citrus and ornamentals. Established as a cooperative multiagency enterprise, the updated laboratories and facilities at the Center for Excellence in Quarantine & Invasive Species are an important milestone to foster and to address invasive pest and diseases that are affecting crop plants and natural landscapes. We have been developing and looking to expand hands-on training in several key topics like pest taxonomy, diagnostics of plant diseases and training. In addition, a strong partnership with graduate programs at University of Puerto Rico is providing opportunities for students from multiple origins in the Caribe to develop Master and Ph.D's programs. Improved facilities together with opportunities for high quality training should provide a safe and sustainable platform aiming to minimize the impact of invasive species and support food production and the preservation of natural resources.

Keywords: Invasive Species, Caribbean Natural Resources, Food Security.

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NEOTROPICAL WILDLIFE PRODUCTION: PROTECTING THE ENVIRONMENT THROUGH SUSTAINABLE AGRICULTURE

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Summary

Neotropical wildlife has gained much interest in sustainable food production. The use of several indigoes species in food consumption. There is significant increase of food import from developed countries to developing countries. The cost of grains on the international market are increasing. Exportation of food from developed countries to developing countries are decreasing. So there is a need to investigate indigenous flora and fauna for food. The Caribbean is a net importer of food. It has an opportunity to develop local flora and fauna for food. Indigenous species of plant and animals are not fully understood/investigated. Indigenous species are well adapted to the environmental conditions of the tropics. The neotropics has 70% of world biodiversity, 604 species of birds, 502 species of reptiles, 140 species of amphibians and 89 species of mammals (Ojasti 1996; Garcia 2008). All the meat that are nowadays consumed, comes from animals that were once wild such as: the Muscovy duck, Turkey and Guinea Pig all originate in this part of the world.

The current situation:

Hunting is the most common method for getting wild meat. Most hunting is controlled by laws with high levels of poaching. People need to seek alternative methods for providing wild meat to meet the growing demands.

Tabel 1: Wild-Caught Animals Trinidad & Tobago, 2010 - 2012

Year	Agouti	Deer	Lappe	Wild Hog
2010	22,441.00	1,939.00	3,796.00	348.00
2011	18,772.00	2,115.00	2,115.00	162.00
2012	23,911.00	2,331.00	4,250.00	387.00

Source: Hunter Return Cards, Forestry Division

There was an increase in wild caught animals between 2010 – 2012 as is shown in the table above for Agouti and Deer.

Animals in the neotropical wildlife are: the Black river conch; the Cascadura; Spectacled caiman; matte /salipinter; Agouti; Red brocket deer; Quenk/wild hog; Lappe/Labba; Green iguana; porcupine; nine banded Armadillo/tattoo; Opossum/manicou; Capybara; red tailed boa; guinea pigs.

The factors affecting animal production are among the physiological states such as housing & environment; feeding & nutrition; genetics & breeding; health & disease; social – economic factors. Still, Neotropical animals can be utilize for several opportunities such as: education, research, recreation and conservation. Some examples are: the agro-eco tourism opportunity e.g: Alligator farming in The Everglades, Florida; Snake farming in Asia; Butterfly farming at St. Martin.

According to table 2, wild meat has higher protein content then chicken and has also lower fats. So it is an ideal meat to consume for humans.

Tabel 2: The nutrient content of Neotropical animals compared to chicken

ANIMAL	PROTEIN %	FATS %
Agouti	23	0.75
Lappe	25	1.23
Tattoo	20	1.43
Quenk	26	0.47
Capybara	26	0.45
Guinea Pig	21	2
Iguana	24	3.49
Tegu/Matte	23	4
CHICKEN	14	~30

Research with Agouti farming for food utilization:

Agouti are frugivores (eat fruits, berries, seeds, vegetables), so they were daily fed with feed available from fruits, vegetables, and forages (50 g/adult/day). Experiments have been carried out with Agouti of 7 different color: black, white, white, gold, brown with golden rump, white with golden rump, brown with white feet.

The housing and environment of Agouti farming are done in:

- Floor pens: breeding colonies (Male: female ratio- 1:5 or 1:10 / Gestation- 115 days, 2-3 young
- Wire cages with concrete floor
- Not wood- gnaw, not dirt- burrow and no sweat glands
- Wood to gnaw
- Feed trough/cup (metal) and provide clean fresh water (cups/troughs)

Conclusion:

There is a high demand for Neotropical animal meat and skin, so wildlife may be farmed to increase production and reduce the hunting pressure. For example, Caiman skin is one of the most durable, valuable and exotic leathers available on the market. Its savage beauty makes it the diamond star of the leather industry. Rhea feathers are used in many forms as ornamental, and Rhea meat is almost the same as beef. Other Neotropical animal utilization are: Peccary leather, Caiman leather wallets, Armadillo and Tattoo shell are used for art and guitar housing. Neotropical animals have the potential to become a protein source in the neotropics, can reduce meat imports and develop sustainable food security.

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EVALUATION OF BIO-AGENTS AND BOTANICAL OILS FOR MANAGEMENT OF GUNDHI BUGS, *LEPTOCORISA ORATORIUS* (FABRICIUS) AND *L. ACUTA* (THUNBERG) (HEMIPTERA: ALYDIDAE) IN RICE

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Abstract: Two bio-agents (*Bacillus thuringiensis* and *Beauveria bassiana*), along with three botanical oils (neem, *Jatropha* and castor oils); either singly or in combination, were screened for their efficacy against gundhi bugs, *Leptocorisa oratorius* (Fabricius) and *L. acuta* (Thunberg) (Hemiptera: Alydidae); under laboratory, screen house and field conditions during 2011 – 2013 *Kharif* seasons in Allahabad, Uttar Pradesh, India. The results showed that *Bt* @ 0.75 kg/ha was not effective against *L. oratorius*, while *B. bassiana* @ $6x10^{-3}$ conidia/ml was effective in causing its mortality by up to 69.05%. Out of the botanical essential oils, each @ 1%, neem and *Jatropha* were most effective in preventing damage to the grains. Although castor oil was significantly different ($p \leq 0.05$) from the control, the percent damage grain was significantly higher than neem and *Jatropha*, which suggested that it was not as effective in deterring the bugs from feeding. Although, *B. bassiana* caused mortality to gundhi bugs, its use should be in combination with an essential oil where the latter will prevent feeding on the grains. The combination of *B. bassiana* with neem and *Jatropha* showed much promise in reducing damage cause by gundhi bug under laboratory, screen house and field conditions; since the percent damage caused was significantly different to that of the control at all times. The combinations of neem + *B. bassiana* and *Jatropha* + *B. bassiana* can form part of integrated pest management (IPM) modules, which will prevent damage and at the same time cause infection to the bugs. These findings have highlighted the importance of neem and *Jatropha*, either alone or in combination with *B. bassiana*, as strong potential candidates for the management of *Leptocorisa oratorius* and *L. acuta*. It was evident that *B. bassiana* did not perform satisfactorily as a standalone in preventing damage to the rice grains but it should be explored as a major component of an IPM program for gundhi bugs.

Keywords: *Leptocorisa oratorius*, *L. acuta*, gundhi bug, bio-agents, botanical oils, rice.

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INFLUENCING FOOD SAFETY AND SECURITY THROUGH TRAINING IN FRESH COTTAGE CHEESE PRODUCTION FROM GOAT'S MILK IN TRINIDAD AND TOBAGO

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Abstract: Fresh milk is a highly perishable product with a short shelf life. Over 5000 L of goat's milk is produced in Trinidad and Tobago annually and this is either pasteurized for sale or converted into value added products. Several brands of fresh cottage cheese are imported into the country from the USA, New Zealand and Canada. However, an increasing number of local producers have entered the market to meet the rising demand for healthy fresh cheese options. Poor food handling practices are one of the leading causes of food-borne diseases. The World Health Organization reported that 1.8 million deaths in 2005 alone resulted from diarrheal diseases, of which most were attributed to the ingestion of contaminated food and/or drinking water. Proper training in safe food handling can reduce the risk of food borne diseases in the Caribbean. The Inter American Institute for Cooperation on Agriculture (IICA), Trinidad and Tobago office, has conducted capacity building activities on the production of cottage cheese from goat's milk as part of their technical cooperation activities 'Institutional Strengthening and Support to Organizations in the Agri-Food Sector' from 2011 to 2014. These capacity building initiatives have targeted approximately 80 persons ranging in ages from 18 to 65 from various organizations in Trinidad and in Tobago. These opportunities have provided youths, women, community based organizations and local producers of goat's milk, including hobbyists, with the tools to improve and/or produce safe quality milk-based products for the domestic market and to compete with foreign imports, thereby influencing food safety in the cottage cheese industry and contributing to food security. This paper presents a review of these technical sessions which can serve as a model to other Caribbean countries for the safe production of dairy products.

Keywords: Food safety, dairy products, capacity building, cottage cheese, IICA

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USING LINKAGES AND FARMER TRAINING TO PROMOTE IMPROVEMENTS IN THE SMALL RUMINANT SECTOR FOR TRINIDAD AND TOBAGO

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Abstract: The small ruminant sub-sector in Trinidad and Tobago is not very well developed. However, the contribution by small ruminants to this sector has been increasing since 2007 through concerted efforts, especially by stakeholders in the industry. This industry has been the focus of a number of projects aimed at increasing production and competitiveness through the Ministry of Food Production and regional and international organizations. The Inter American Institute for Cooperation on Agriculture through its Technical Cooperation activities has been using linkages and farmer training to improve meat and dairy production in the small ruminant sub-sector. To achieve these objectives, IICA has formed strong ties with the main small ruminant stakeholder, the Trinidad and Tobago Goat and Sheep Society and a number of government and non-government bodies to conduct capacity building activities and other interventions towards the development of the sub-sector. These interventions have trained stakeholders, farmers, women, youth and students in carcass fabrication; cottage cheese and other value added dairy products; hygiene and sanitary slaughter of small ruminants; feed and feeding systems and determining the profitability of small ruminant production in Trinidad and Tobago. To this end IICA also developed a generic framework for the development of the industry. These networking activities is helping to improve the competitiveness of the small ruminant farmers and provide much needed support to the small ruminant subsector.

Keywords: ruminant, Inter American Institute for Cooperation on Agriculture (IICA), capacity building

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NUTRITIONAL QUALITY OF A CUBAN COLLECTION OF CORN (*ZEA MAYS* L.) C.

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Abstract: In Cuba, corn is grown since the time of the Aborigines and is a staple in human nutrition, livestock and poultry. It is the second major cereal and has high preference of consumption by the population. In Cuba, there are six races of maize with a high diversity, which has been extensively studied. However, nothing is known about the diversity and nutritional characteristics of the plant or improved have been introduced for this purpose varieties. The present study was conducted on a sample of 106 accessions, which included accessions conserved *"in situ"* on farms of peasants and "*ex situ*" conserved. The aim of the study was to evaluate the degree of morpho-agronomic and nutritional variability of the collection and to identify accessions with high nutritional quality, using for this purpose 17 morphological characters and 13 related to the nutritional quality, with emphasis on the content of essential amino acids, lysine and tryptophan, due to its deficiency in maize. The results showed that it assessed maize collection, presented morpho-agronomic and nutritional variability and local production of maize in the study areas, depended mainly on the seed produced and maintained by farmers. From a nutritional standpoint, 74% of the accessions were characterized by high contents of tryptophan and high levels of quality. Among those, five accessions exceeded nutritional quality indicators established for the content of tryptophan, protein and quality index. The contents of tryptophan and quality index of the accessions showed equivalent values to those produced by the Opaque-2 gene values, but without the manifestation of the negative characteristics associated with this gene.

Keywords: lysine, variability, tryptophan, diversity

CALIDAD NUTRICIONAL DE UNA COLECCIÓN CUBANA DE MAÍZ (*ZEA MAYS* L.)

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Resumen: En Cuba, el maíz se cultiva desde la época de los aborígenes y constituye un alimento básico en la nutrición humana, del ganado y las aves; es el segundo cereal de importancia y tiene alta preferencia de consumo por la población. En Cuba, existen seis razas de maíz con una alta diversidad morfoagronómica, la cual ha sido ampliamente estudiada; sin embargo, no se conoce sobre la diversidad y características nutricionales del cultivo, ni se han introducido variedades mejoradas para este fin. El presente trabajo se realizó en una muestra de 106 accesiones, donde se incluyeron accesiones conservadas *in situ* en fincas de campesinos y conservadas *ex situ*. El objetivo del estudio fue evaluar el grado de variabilidad morfoagronómica y nutricional de la colección e identificar accesiones con calidad nutricional alta; utilizando para ello 17 caracteres morfoagronómicos y 13 caracteres relacionados con la calidad nutricional, con énfasis en el contenido de los aminoácidos esenciales lisina y triptófano, debido a su deficiencia en el maíz. Los resultados obtenidos permitieron detectar la existencia de variabilidad morfoagronómica y nutricional en la muestra. Se demostró que la colección de maíz evaluada, presentó variabilidad

morfoagronómica y nutricional y que la producción local de maíz, en las zonas estudiadas, dependió principalmente de la semilla producida y conservada por los campesinos. Desde el punto de vista nutricional, el 74 % de las accesiones evaluadas, se caracterizaron por elevados contenidos de triptófano y altos índices de calidad, encontrándose cinco accesiones que superaron los indicadores de calidad nutricional establecidos para el contenido de triptófano, proteína e índice de calidad. Los contenidos de triptófano e índice de calidad, de las accesiones evaluadas, mostraron valores equivalentes a los producidos por el gen *Opaco-2,* aunque sin la manifestación de las características morfoagronómicas negativas asociadas a este gen.

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BEHAVIOUR OF TWO PAPAYA VARIETIES TO FERTILIZER REGIME AND PLANTING DATE

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Abstract: Papaya demands nutrients continuously in large amounts and use large quantities of expensive chemically formulated fertilizers. A field experiment was conducted at the University Field Station, Mt. Hope, to study the effect of planting date and reduced fertilizer regime on two cultivars of papaya (Carica papaya L.) (cv. Red lady and Tainung No. 2) production in a River estate loam soil. The experiment comprised of four reduced fertilizer regimes, which included, agribiotics (microbes and humic acid), arborgreen (30-10-7, slow release fertilizer), urea and 12-12-17+2 (usual farmers' practice) and no fertilizer as the control. The results showed that arbogreen treated Red lady and Tainung No.2 performed significantly better than other treatments for plant height, fruit number and also postharvest storage and quality, regardless of planting date. Arborgreen treated Red lady plants were also more tolerant to the Bunchy top virus and yielded higher fruit weights than other treatments. Tainung No. 2 plants produced higher yields with the Agribiotics treatment at both planting dates but were very susceptible to the Bunchy top virus. Results demonstrate that increased yields can be obtained using more sustainable fertilizer management, while decreasing fertilizer usage from 50-100% thereby significantly increasing profits for farmers.

Keywords: Papaya, sustainable Fertilizer use

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REALIZING AGRICULTURE'S TRUE REVEOLUTION FOR SUSTAINABLE DEVELOPMENT IN THE CARIBBEAN REGION: LESSONS FROM THE GREEN REVOLUTION

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Introduction

Agriculture is one of the most important areas for sustainable national development, human security and the well-being of any and every society. The world in which we live is facing an enormous challenge in feeding itself. Millions of people are going hungry and dying as a result of improper nutrition. Our agricultural and food production system worldwide is therefore under considerable pressure to be improved in order to better cater for an ever increasing population with fewer natural resources. While everyday advances and innovations produce positive prospects for increasing food production, the fundamental challenges of hunger, poverty, improper nutrition and the degradation of our environment as a result of our present agricultural system still persistently remain! This raises serious concerns not just about the issue of food production, but rather, the system of food production that is in place today across the countries of our world, including our countries in the Caribbean region.

The Green Revolution

The Green Revolution has been reincarnated many times over, according to this scientist. Since the 1950s, we have heard terms such as the - "**real green revolution**", "**greener revolution**", an "**evergreen revolution**", a "**blue revolution**", and an "**African green revolution**" to name a few. These terms all originated from the "Green Revolution" which was initially born out of the realization of the unique importance of agriculture and food production to feed the world. The fundamental premise for the Green Revolution was simply to grow more primary staple crops (for example - wheat, rice and maize) by intensifying their agricultural systems in areas where returns would be high (Pingali 2012). The green revolution is defined by Dr. Norman Borlaug as: **"Food is the moral right of all that are born into this world"**. He also believed that **"we cannot build a peaceful world on empty stomachs and human misery"**.

The Green Revolution shaped its interventions around a few main components:

1. The development and use of improved varieties/hybridized seeds. Improving inputs within the agricultural system was the basis for the corresponding improvement in productivity. In fact, the productivity gains from crop germplasm improvement alone are estimated to have averaged 1% per annum for wheat (across all regions), 0.8% for rice, 0.7% for maize, 0.5% for sorghum and 0.6% for millets (Everson and Gollin 2003).

2. Increased irrigation. In this context, increased emphasizes the building of infrastructure to facilitate and support a consistent irrigation supply; including - capital investments in the construction of dams, aquifers, channels and other water works.

3. The development and use of synthetic agro-chemical inputs. An estimated 30-50% of crop yields are attributed to natural and synthetic commercial fertilizer, making this input strategically important to food production. The Green Revolution capitalized on the expanding petroleum industry in utilizing its by-products and outputs to produce valuable fertilizer products. This is perhaps best seen with the production of nitrogen fertilizers. Leveraging economies of scale to produce a diversified product portfolio made the economic model more competitive and allowed fertilizers to be made available at competitive prices which were further supported by subsidies.

4. The modernization of agricultural management, techniques and technologies. And I must say here, that the most substantive factor in the Green Revolution was perhaps the focus on human talent/capacity and the better coordination of the increased number of inputs within the production system, such as mechanization. This demonstrated to the world that agriculture was in fact a very knowledge-intensive industry and put immense focus on knowledge creation and its leveraging for development as a strategic asset for improved agriculture.

The economic model of the Green Revolution was a resource-based one which specifically targeted improvements in the factors of production on a quality and quantity basis. The demonstrated potential of agriculture as an economic system to impact on these two primary objectives (quality and quantity) remains the defining merit of the Green Revolution, despite its short-comings. What is of great significance, is that - the world saw that agriculture was most definitely capable, and up to the challenge of feeding the world. That the global community could collectively agree that agriculture, amidst all other economic sectors is unique in solving or at least playing a major role in solving the world's major challenges was outstanding! Prof. Sankat therefore sometimes likes to refer to agriculture as 'green gold' because of its value and its potential to alleviate some of the major challenges of our society including starvation, poverty and improper nutrition.

The Green Revolution had on the world, it also resulted in several negative impacts.

Agriculture as green gold

The world saw that agriculture was most definitely capable, and up to the challenge of feeding the world. That the global community could collectively agree that agriculture, amidst all other economic sectors is unique in solving or at least playing a major role in solving the world's major challenges was outstanding!

The lessons learnt from the Green Revolution

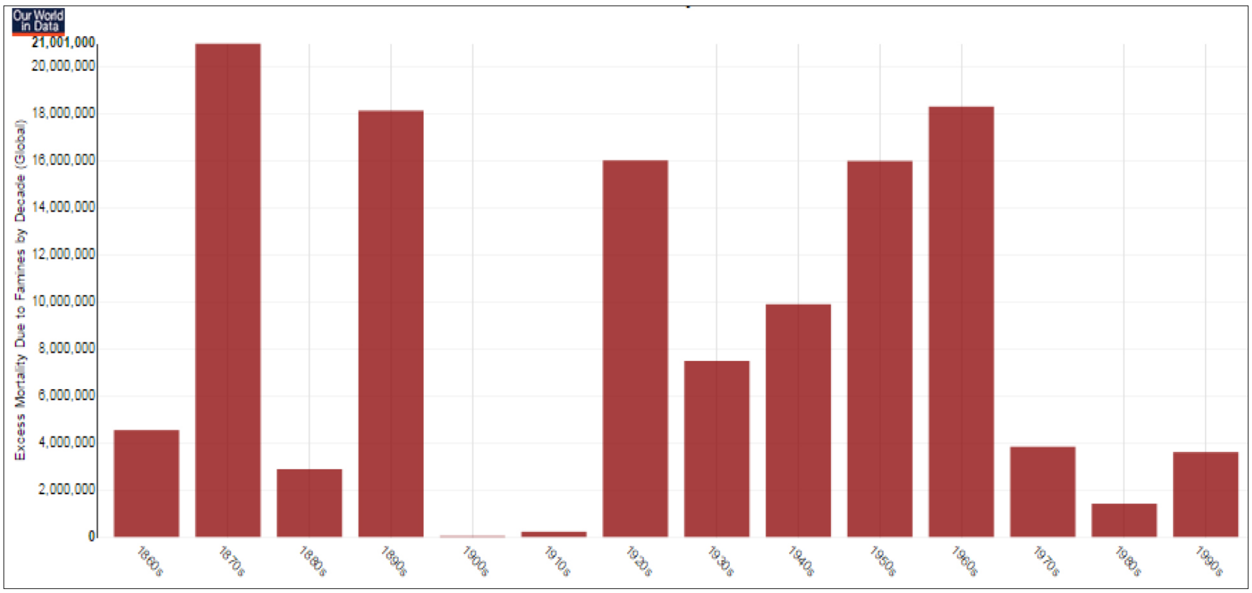
The lessons to be learnt from the Green Revolution as we attempt to shape a sustainable future for the countries of our region are divided in four categories.

Lesson 1: Food Nutrition & Health

In 1960, the discussion on food and health focused on the fact that many were starving and this was associated primarily with poor economic access to, and availability of food.

Figure 1 shows that there were very high levels of mortality as a result of famine in the 1950s and 1960s which not only supports this view, but also gives the rationale for the need for the Green Revolution to reduce deaths due to famine; indicative of improved food availability and access post 1960s.

Figure 1: Mortalities due to Famines

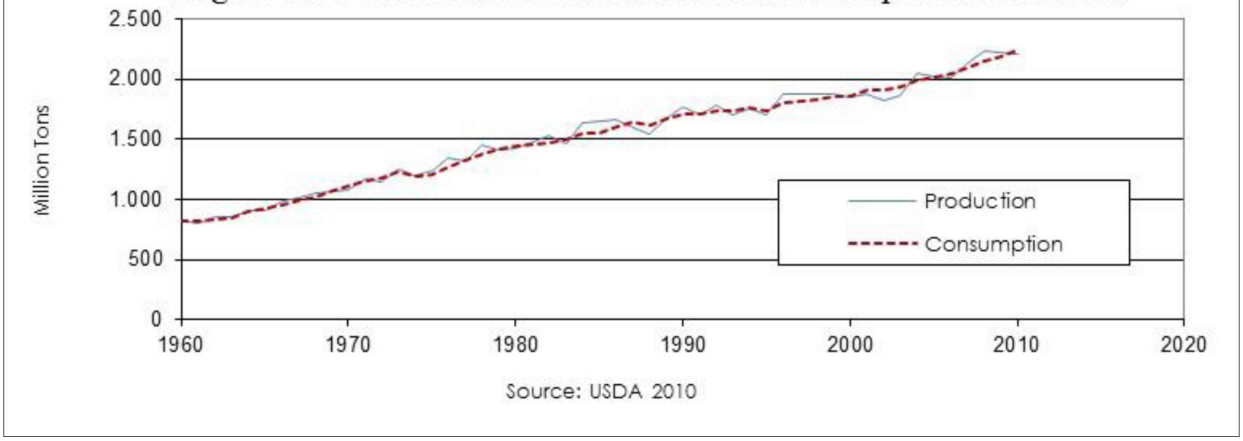


Source: Our World in Data 2015

Increase of World Grain Production & Consumption

World grain (wheat, rice and maize) production grew as a result of the Green Revolution to meet and often exceed consumption (see figure 2). Production grew at a rate of 36% over the 1960s, which was the most notable increase, followed by 24% in the 1970s and 14% in the 1980s. The State of Punjab in India became known as India's 'Bread Basket' and the backbone of the national food system even though it represented only 1.5% of the total geographical area of the country. The desire to increase production was achieved. In fact, today, the value of total agricultural output (all food and non-food crop and livestock commodities) in real terms is almost 3 times that of 1961 – an average increase of 2.3% per annum, and has surpassed global population growth of 1.7% per annum (FAO 2008).

Figure 2: World Grain Production and Consumption: 1960-2010



Malnutrition remains the World's Most Serious Health Problem:

Malnutrition (composite of both under- and over-nutrition) can be described as the condition that develops when the body does not get the right amount of vitamins, minerals, and other nutrients needed to maintain healthy tissues and organ function. **Under-nutrition** occurs when the human body consumes too few essential nutrients or uses nutrients rapidly before they can be replaced. In contrast, **over-nutrition** results from excessive food intake relative to dietary nutrient requirements and is associated with an obesogenic agri-food production, supply and distribution environment. It is interesting to note that the problem of over-nutrition is increasing in countries where a few decades ago, under-nutrition and hunger were most endemic; and to the extent that they occur simultaneously amongst the poor (Chopra et al 2002).

Malnutrition is a Global and Caribbean concern and the data supports this phenomenon both globally and in the Caribbean region. Figure 3 and Figure 4 show that although under-nutrition has reduced; over-nutrition has increased significantly. It stands to reason also that at the present rate, the Caribbean is expected to see a similar convergence and inclination to over-nutrition and its associated spike in chronic, non-communicable diseases. This does not mean that under-nutrition will be eliminated, but rather that the coexistence of the two will become more common.

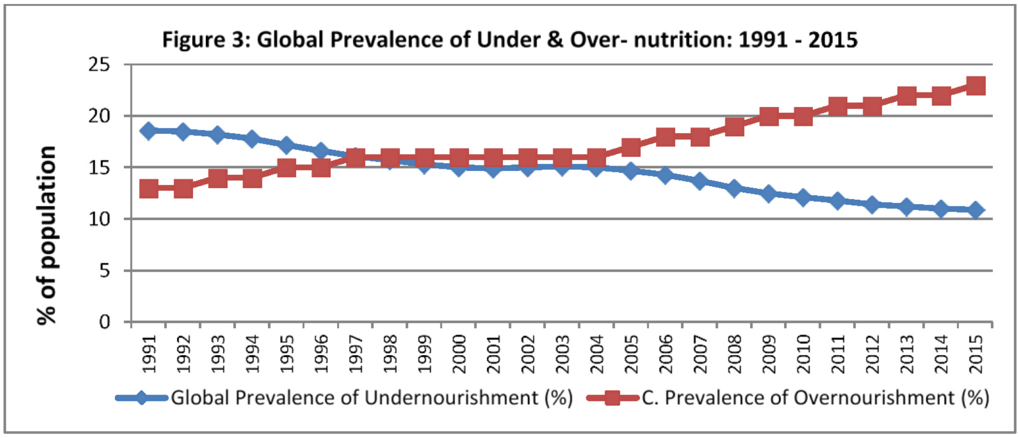


Figure 3: Global Prevalence of Under & Over- nutrition: 1991 - 2015

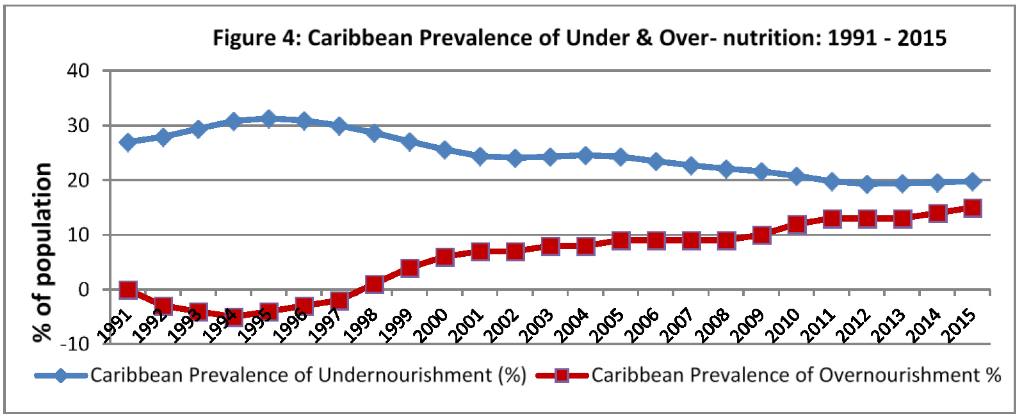


Figure 4: Caribbean Prevalence of Under & Over- nutrition: 1991 - 2015

Source: FAO Stat 2015

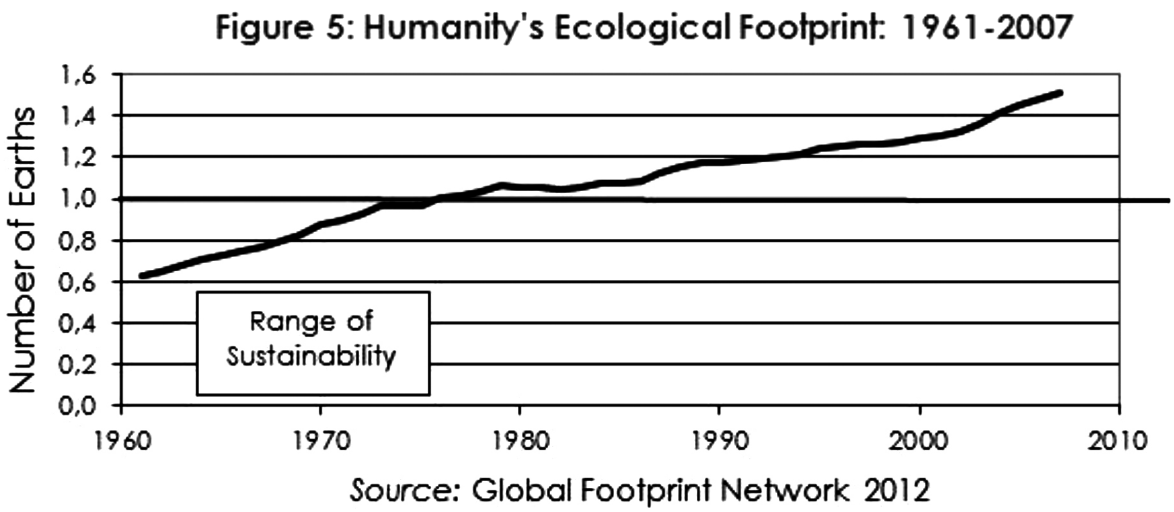
What was once an issue of under-nutrition has become one of over-nutrition. Nutrition, and specifically the nutritive quality of food rather than minimum calorie and protein intake, should thus be the main focus of our agricultural systems in the Caribbean. In other words, it is the nutritive content of food that is most essential to human health and therefore, this should be the developmental focus for our agri-food production systems. This must be our target; we must aim for our agricultural system to not only be more productive, but of equal importance, our agricultural systems must also improve the health of our people.

Lesson 2: Ecological Economic Impact

The impact of the intensive system of agriculture coming out of the Green Revolution produced substantial negative impacts – directly and indirectly. These negative impacts were primarily caused by high energy consumption and the inappropriate use of agrochemicals which, besides the direct effects on human lives, polluted waterways, and destroyed soils and upset ecosystems (World Development Report 2008 and Shiva 1989). These myriad adverse impacts point to the economic dimension of the environment which is the ecological/environmental systems and associated services of nature which supports life and our existence on this planet.

The Green Revolution & its Ecological Footprint

Figure 5 shows that there has been a steady increase in humanity's ecological footprint since 1961 – correlating with the transition to the system of agriculture we have characterized under the Green Revolution. Measured in number of Earths, a value of 1.0 means that the world economy used the equivalent of what the Earth can sustainably provide in a year. As seen in the figure 5, this was reached around 1976. That means that in 2007, the demands of the world economy on environmental/natural services was already more than 50% what could be sustainably supplied – a value equivalent to 1.51 Earths.



Degradation of our Natural Capital

This outlook does not bode well for many of the important ecological goods and services – the natural capital - upon which agricultural systems and life are dependent:

1. For example our Biodiversity has been negatively impacted by the industrial agricultural system that has become characterized with the Green Revolution. Since the beginning of this century about 75% of the genetic diversity of agricultural crops have been lost, with crop genetic resources being destroyed at the rate of 1-2% every year. For livestock, an estimated 5% is being lost each year (Shand, 2015). These are potential sources of food, jobs, cures for terminal diseases and revenue being forever lost.

2. In another instance, water is an important resource that has been negatively impacted by the industrial agricultural system. According to the Water Research Institution (2015) agriculture accounts for more than 70% of all human water withdrawal (WRI, 2015). More than 25% of the world's agriculture is being grown in areas of high water stress (WRI, 2015). This is more acute when looking at irrigated agriculture where about 56% of irrigated areas are under high or extremely high water stress (WRI, 2015). Now, irrigated agriculture is and will become more important to boosting as well as stabilizing agricultural productivity given increased variability in rainfall. For the Caribbean, where most countries, with the exception of a few such as Dominica, are water deficit (i.e. water extraction exceeds replenishment) this leaves almost no room to manoeuvre or to adapt to future challenges. Coupled with the projected increases in agriculture's water demand the situation as it relates to water seems challenging to say the least. This means,

that as we look to the future we must adopt a fundamentally different outlook on irrigation (infrastructure and systems) than those common to the Green Revolution.

The degradation of our natural resources/systems like our biodiversity and the inefficient use of water due to our system of agriculture and food production is a major loss to development, and this in itself to my mind demonstrates that the present economic system is in no way sustainable.

Deforestation increasing in the Amazon Rainforest

The deforestation that is taking place in the Amazon Rainforest today. A rainforest that comprises the largest and most biodiverse area of tropical rainforest in the world, and one that passes through nine nations, including Suriname. Looking forward, we in the Caribbean region must therefore endeavour to let agriculture be a net contributor to bio-capacity rather than a net extractor.

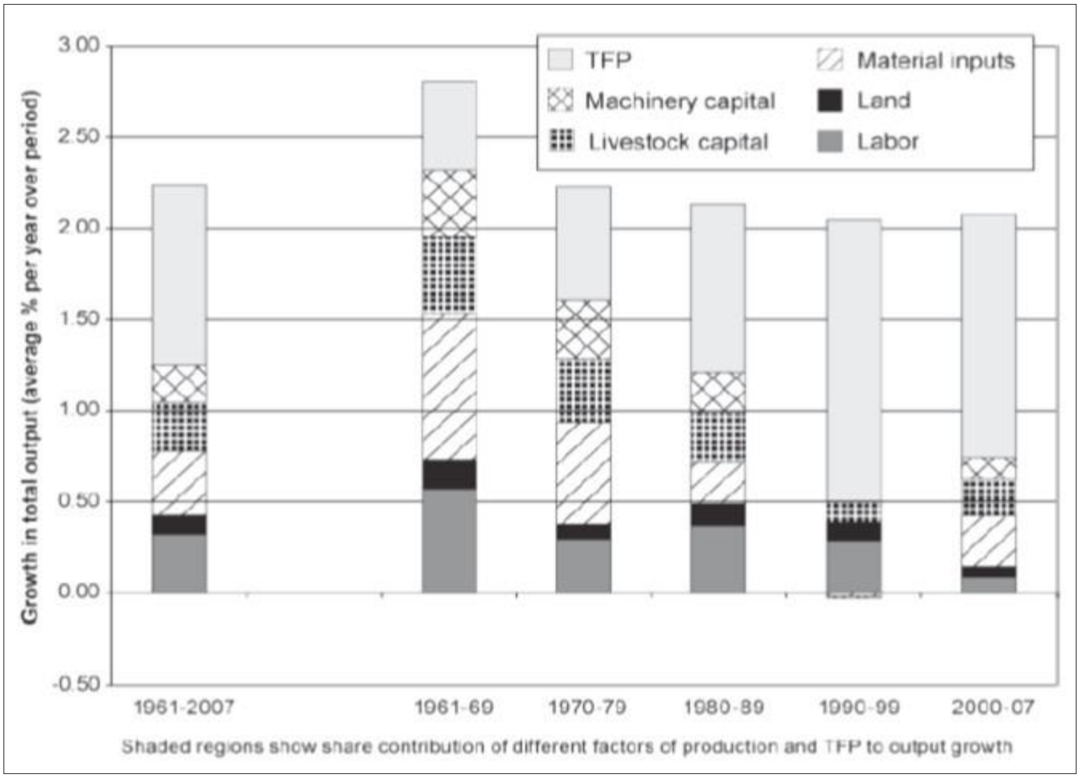
Lesson 3: Productivity & Economic Growth

A primary premise for the Green Revolution was to increase agricultural productivity – essentially, producing more in the same space. This requires efficiency gains from technological advancement, learning and knowledge leveraging (Total Factor Productivity/TFP) to produce economic gains contributing to economic growth through improved comparative advantages for local manufacturing and export. While discussions on contributors to economic growth regarding the Green Revolution typically highlight the benefits of hybrid/miracle seeds, fertilizers and capital formation, it is really the latter - the Total Factor Productivity – that is the main driver or real star of economic growth because it reflects the ability to learn, to improve and to innovate in an economic system. Conservative estimates suggest that Total Factor Productivity accounts for as much as 60% of the real, sustainable growth within economies (Easterly and Levine 2001).

Global Sources of Agricultural Growth

Figure 6 presents the sources of agricultural growth by decade, showing the contribution of Total Factor Productivity and the productivity contributions of five major input categories: land, labour, livestock capital, machinery capital, and material inputs (Fuglie 2010).

Figure 6: Global Sources of Growth in Agricultural Productivity – TFP and Input Sources: 1960-2007



Source: Fuglie, 2010

Growth in material inputs (especially in fertilizers), labour, livestock capital and machinery capital were the predominant input contributors to agricultural growth in the 1961-1969 period. These were the principal elements of the Green Revolution which when coupled with improved varieties, produced the impressive yield rates previously discussed. However, the effect on productivity growth diminished gradually towards the 1990s. This may be associated with their inappropriate and inefficient use as this period correlates with the increasing ecological footprint of agriculture. However, material inputs make resurgence in the 2000s – perhaps correlating with the development of more recent bio-technological improvements.

Land productivity has been a consistently minor contributor to overall TFP, experiencing notable falls (e.g. 1970s and 2000s). This correlates with soil degradation from intensive systems and inappropriate practices associated with the Green Revolution.

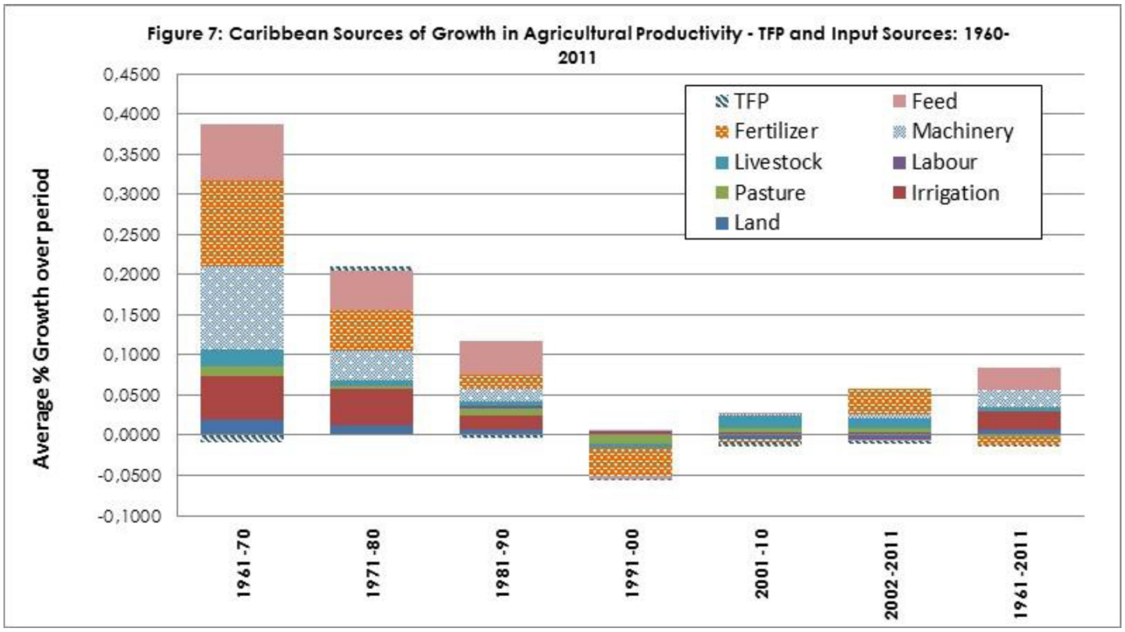
There has been a substantial decrease in the rate of agricultural capital formation (represented by machinery capital and livestock capital) between 1961 and 2007. This suggests that utility-maximizing investors (including farmers) found more lucrative alternatives for capital (particularly between 1981 and 1999) other than in agriculture. This makes sustainable capital formation for agriculture an important need as we try to realize agriculture's true revolution for sustainable development.

The biggest star of global agricultural growth has been TFP which progressively grew to be the dominant factor in productivity growth from the 1960s to the 1990s. This means that TFP, i.e.

know-how and resource-use efficiencies have in fact been the predominant issue in agricultural growth.

Caribbean Sources of Growth in Agriculture Productivity

Figure 7, illustrates the scenario in the Caribbean region. It shows that investment in machinery, fertilizer, feed and irrigation in the 1960s supported development in the 1980s. However, labour and TFP constituted very little or no elements in agricultural growth from 1960 to 2011, the two elements that should have in fact demonstrated in gains toward sustainable growth.

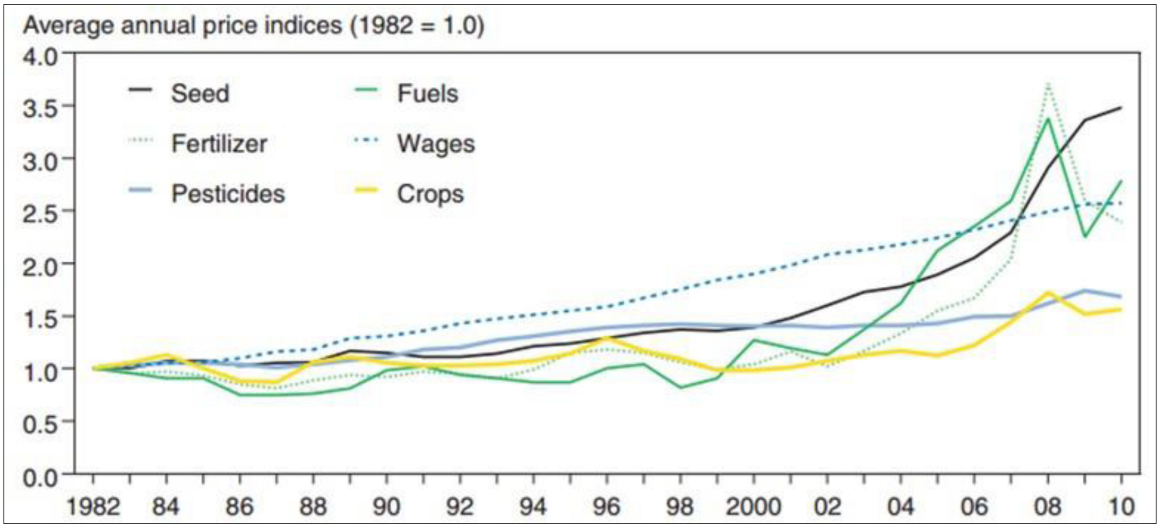


In general, resource intensification spurred agricultural growth in the Caribbean with capital formation (machinery, irrigation) and fertilizer and feed being the main drivers. However, their diminishing profile in the portfolio into the 1970s, 1980s and 1990s suggest that there is poor re-investment into and management for development in the sector in this period. When we consider that these inputs were, and still are largely imported, it is not surprising that agriculture remains so chronically vulnerable to macro-economic risks (therefore business as usual within our present agricultural intensification model will not work!).

Global Price Indices

Figure 8 shows that even though crop prices have an overall positive trend, it does not account for increases in major input costs – especially seed, fertilizer and fuel prices. These are primarily imported by developing countries such as our countries in the Caribbean and contribute significantly to agriculture's negative trade balance.

Figure 8: Global Price indices for Seed, Fertilizer, Pesticides, Fuels, Wages and Crops: 1982-2010



Source: USDA, NASS 2012

Evenson and Fuglie (2010) further emphasized that TFP performance in developing-country agriculture was strongly correlated with national investments in technology capital – that is, a country's ability to develop and extend improved agricultural technology to farmers. They found that countries that failed to establish adequate agricultural research and extension institutions and extend basic education to rural areas were stuck in low-productive agriculture and were falling further behind the rest of the world (Everson and Fuglie 2010). To emphasize this point, Bizzarri (2013) also comments that agricultural research and development will be more effective when youth and women are well-represented and well equipped to adopt/leverage agricultural research for development (ARD) products and services.

According to Prof Sankat as Principal of The UWI St. Augustine Campus, this is indeed a critical modality for growth and development as we endeavour to realize agriculture's true revolution for sustainable development in the Caribbean region.

Lesson 4: Socio-economic & Political Governance

The Green Revolution was framed within a neo-liberal logic of scale and specialization that tied farms and agri-food into an industrial/bio-science dynamic (Van der Ploeg and Marsden 2008).

Agriculture as Big Business:

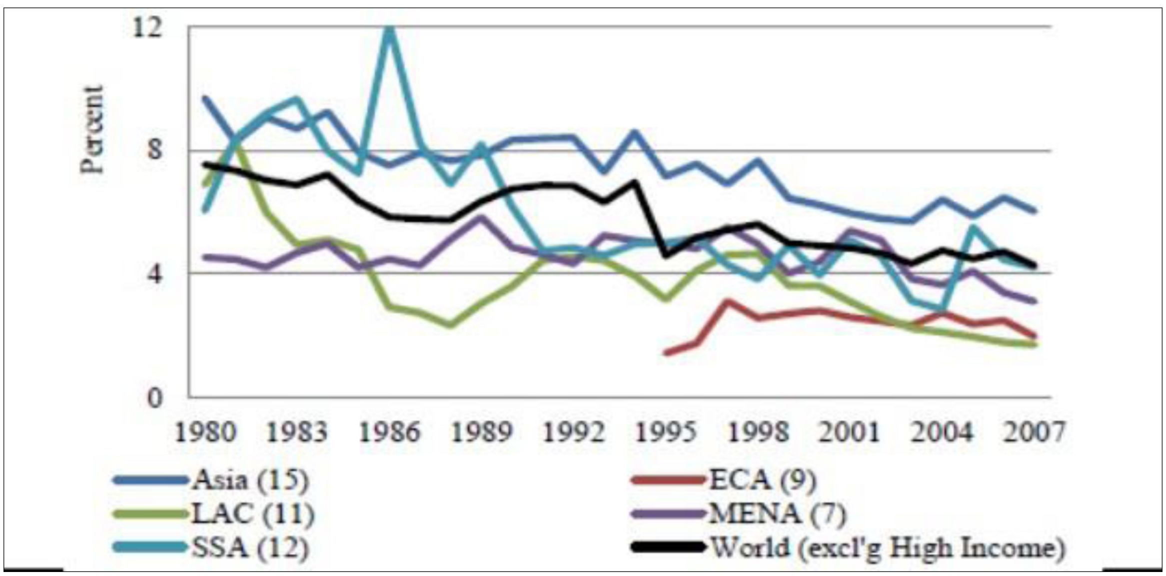
The Green Revolution showed agriculture as big business and had a suitably high profile with transnational financing and investment from the likes of the Rockefeller and Ford Foundations, Bayer, Dupont and Monsanto amongst others. Financial backing grew especially in the 1970s with a budget of US$20.06 million in 1972 from 16 donors, growing by 687% to US$157.95 million in 1981 from 40 donors (Shiva 1991). This was motivated by expanded avenues for investment in areas that yielded economic gains.

These were identified as - research and development and knowledge management, capital formation, improved inputs and labour. As the saying goes, "you need to speak the language that people will understand" and economic gain is that language; and over the last half century politicians and business folk alike have been listening. To this end, the Green Revolution benefited tremendously from political, institutional and private-sector support. This was the partnership which the agricultural sector longed for, and needed - public-private partnership. What created and supported this partnership was a clear development plan showing the sustainable economic gain across the socio-cultural and economic dimensions of agriculture and how they will in fact be sustained. However, it is the absence of this type of plan in the Caribbean that still continues to produce the kind of "start-and-stop" macro-climate for agriculture that we see in our region. This is perhaps best seen in investment in agricultural research and development.

Financial Resources to Agriculture by Region

Figure 9 shows that investment into agricultural research and development, by Latin America & the Caribbean (LAC) in particular has not kept pace with the requirements for realizing the kind of real economic gains that other territories have seen.

Figure 9: Financial Resources to Agriculture in the LAC relative to other Regions: Agriculture share of Total Government Expenditures (1980 – 2007) by Area



Key: LAC – Latin America and the Caribbean; SSA – Sub-Saharan Africa; ECA – Europe and Central Asia; MENA – Middle East and North Africa
Source: Lowder Carisma 2011

Persistent constraints need consistent attention and this is a demand of the political and institutional commitment to agriculture. This should be a poignant message to Ministers of Agriculture and other agricultural planners throughout the Caribbean region for the coming decade. If our region is to see sustainable agricultural systems implemented for the benefit of our people, we must invest in agricultural research and development.

The Way Forward

Agriculture's True Revolution will come from an ecological modernization, so we need to shift gears and embrace new thinking and new paradigms which will bring new solutions for sustainable agricultural development in the Caribbean region. And as Prof. Sankat reflected upon these lessons, he could not help but imagine some of the possibilities for the Caribbean region as it relates to agriculture and food production.

According to him, we need to start with the realization that agriculture's true revolution will come from an ecological modernization. Ecological modernization is a system-based approach which looks to the inter-connections between policy formation, the economy and the natural environment with the intention of transitioning operating systems to forms that are in line with the natural ecological process (Orssatto and Clegg 1999). It focuses on industrial ecology as the operating premise for economic activity so that there is maximum use of resources, however, with minimal disruption to the environment. We therefore must change the whole philosophy of how food is produced, distributed, sold and consumed to address vulnerabilities created by the present agri-food economy.

The Case of Southern Ethiopia: Making Agriculture Ecologically Sound

We can make agriculture more ecologically sound by adopting farming models that add value to ecosystem products. Agricultural systems that produce positive contributions to bio-capacity and the associated ecosystem goods and services. A notable example of one of the observed sustainable farming systems showcasing how this bio-capacity is used together with local biodiversity can be found in Southern Ethiopia where a five thousand year-old farming system was given new life by adapting these principles for production of Ethiopian banana, coffee, honey, timber, highland sheep and a variety of crops (Horlings and Marsden 2011). It follows an inter-cropping system which creates a more drought-resistant and nutrient-rich bio-space for other crops as well as reduces soil erosion and degradation. This limits the need for synthetic fertilizer, weedicides and pesticides. Further, Ethiopian banana is a crop capable of producing over 5.6 tons per hectare/year in agro-forests, making it a great option for sustainable food production. In fact, it is regarded locally as being capable of producing more food-stuff per unit area than most cereals.

This is a model of creating an indigenous agro-ecosystem that works for sustaining the natural resource base for agriculture which is an irreplaceable asset. Moreover it is feasible at commercial levels. For example, Pretty and Hine (2001), in a study of 208 agro-ecological projects in 52 countries, found that commercial farmers had improved profitability, crop productivity, increased water use efficiency, carbon sequestration and reduced their use of pesticide as a result of adopting more sustainable farming systems and not adoption of sustainable practices– note the difference. Important to each of these systems were better use of nature to increase total farm production and improvements in per hectare yield of staples through the introduction of new regenerative elements into farm systems.

Value-Creation vs. Value-Extraction

We can focus on value-creation as opposed to value-extractive agricultural economies. In any economic system, value creation is what matters – specifically, finding the most cost-effective way of generating that value. Value-creating agricultural economies are those that create and/or enhance endemic/indigenous value systems. Ensuring that benefits are accrued to those who need it most should also be emphasized. Localized value-adding opportunities at the farm level help the farmer to create value chains/systems where primary actors are the primary beneficiaries.

But in order for this to work, we must take into consideration a couple factors.

- First, we must minimize food wastage in the agricultural economy. In a world where as much as 925 million people are hungry (Bread for the World Institute 2011) we throw away 33% of the food produced. In other words, on average, every one of us throws away 70 kg of food a year. In total, this is roughly 1.3 billion tonnes of food each year – an amount that can feed as much as 3 billion people worldwide. If we can think of the food product being thrown away in terms of the water, fuel and energy, labour, ecosystem products and other inputs put into the production process I think that we can all agree that this pattern cannot continue. With a population of about 15.6 million, the Caribbean Region has some 6.7 million persons (43%) who are undernourished and at risk of hunger (ECLAC 2006). Thus, curbing food wastage can have substantial impact on a sustainable development agenda. This will involve a number of interventions aimed at improving food procurement, storage and distribution/redistribution systems, market/supply coordination, mitigating natural hazards as well as consumer education for better utilization of food.

- Second, we must craft new value propositions around core strengths. Yes, we are characterized as small island developing states (SIDS) with a limited resource base, but that does not mean that we have no resources to work with. In agriculture, this means an enhanced business savviness to leverage and/or craft new value propositions around new and interesting products and services for agriculture that are being created anyway. There are a few major areas where the Caribbean can put its focus. For instance, we can focus on under-developed resources with complementarities for agriculture. I speak specifically to culture, heritage, geographic location, biodiversity, as well as product value equity as seriously under-leveraged resources. Leveraging these additional resources can be a game-changer for the Caribbean. In agriculture this can be the difference between "traditional farming", for example, and "organic farming"; or the difference between "local farming" and cultural/natural heritage-based agro-tourism. To those of us familiar with it, it may seem a simple thing, but when shaped into the appropriate value proposition - it is a fresh, exciting product. For example, both organic products and agro-tourism are picking up pace globally in generating alternative income sources for agriculture. Since 2000, organic product sales have more than tripled from US$18 billion with healthy growth reported in the United States, Canada, Asia and Latin America (Triple Pundit 2010). In 2013 it was recorded as a US$72 billion industry by the Organic Monitor. Similarly, agritourism presents an opportunity to leverage historical and socio-cultural resources which are under-developed as a tourism product (natural heritage, biodiversity, culinary, herbal and naturopathic products) especially as it relates to predominant global trends in experiential and wellness travel. One study found that there is a global increase in the number of experiential travelers, especially among the post-World War 2 baby boomers and that on average travelers interested in culture and history spend as much as 45% more per trip per person (Nissenson 2004). Similarly, Wellness Tourism is another niche in experiential travel where spending is on average 130% more than the typical tourist (Hotelnewsnow.com 2015). It is no wonder then that this niche was valued at an estimated US$3.4 trillion in 2013 (Reuters 2014) with growth forecasts of 9% per annum through 2017- that is 50% faster that the overall tourism industry (Amster 2013). People, food, culture and nature are amongst the top elements in this niche, which offers tremendous complementarities with agriculture. What is lacking is better specification of the value proposition, publicity and improved sector-specific support and management.

A persistently under-utilized area for crafting new value propositions and overcoming the resource challenges associated with them is collaborative development. The premise is simple - pool resources and competences to satisfy a collective interest. The basic economic framework for doing so already exists for the Caribbean in the form of CARICOM and CARIFORUM. This could easily facilitate collective financing of value-creating initiatives and would be especially useful in scaling-up unique value propositions which may exist in a particular country or group of countries. Some of the key operational elements to look at include - Market Infrastructure for High Value Products. For example Trinitario fine-flavoured cacao, which can be found in several Caribbean countries. The world cocoa market distinguishes between two broad categories of cocoa beans: ordinary or bulk beans (around 85% of all cocoa worldwide) and fine flavour beans, which are the defining component of high quality chocolate. Together, Latin America and the Caribbean produce 80% of the world's fine flavour cocoa and, with six of the recognized 17 countries in the world that produce and export the exotic product being from the Caribbean (Carib-Export 2011). In addition to producing beans for export, economies that may be reached by collective action could make value-added opportunities more cost-competitive; especially in organic, fair trade and other high-end markets. In addition to cacao, fishery and seafood products, essential oils, condiments and specialty wines are also prime candidates for this market segment.

Value-Creation Propositions

As one of the biodiversity 'hot spots' of the world, leveraging endemic species should be an important feature of our development strategy for agricultural enterprise and agribusiness development. For example, the recent development of patents for anti-cancer compounds from the Guinea hen weed (Petiveria alliacea) and the Jamaica ball moss (Tillandsia recurvata) demonstrate untapped avenues for product development.

What is primarily lacking is a structured, coordinated approach to identifying and evaluating medicinal, functional, nutritive and other beneficial attributes of our native biodiversity to guide product development around a more secure competitive advantage. Important commercial areas that Caribbean economies should consider include specialty chemicals, industrial enzymes, biopesticides, essential oils and the incorporation of components of biological material into high-value commercial products in food and food supplements, as well as personal care products (Tzotzos 2012).

Options for Agri-Financing

There are many options for Agri-Financing, options ranging from public-private financing (PPF), the creation of investment funds as well as crowdfunding. What is important for agriculture is not which to use but how best to use all of them.

There are also new alternative financing mechanisms that can be used at the level of development groups and Civil Society Organizations to effect national impact. For example, crowdfunding is being suggested as an option for treating with the Euro $3.5 billion debt of Greece. If that is the case, then surely localized projects for creating livelihood options and even agricultural research and development that can be leveraged through collective commons are possible. Another example: one simple father-son Australian duo was able to raise a record-breaking US$10 million dollars over the course of a few days for their innovative, new FlowTM Hive body on the Indiegogo crowdfunding platform. They had an initial target of US$70,000 which was reached in 8 minutes (CNN Money 2015).

This example is particularly meaningful for the Caribbean because it shows that the real needs, and the competence to implement are sound value propositions. And while donor funding has always been important to agricultural development, it must be noted that with the mounting global economic vulnerability, it is uncertain the extent to which this funding will last. This means that instead of settling into a state of complacency, Caribbean economies need to maximize the efficiency with which donor funding/ official development financing (ODF) is used.

Conclusion

While agriculture in the 21st century must be a partnership and a shared responsibility between all relevant stakeholders including – governments, the private sector, civil society, research centers and universities etc., I do believe that it is the responsibility primarily of the governments of our region to create a facilitating environment. It is only when national/regional policies bring convergence to food and agricultural production, nutrition and health, the environment and our socio-economic conditions, we can build a future for generations to come.

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Proceedings of the Caribbean Food Crops Society. 51:45. 2015

EVALUATION OF DIFFERENT CROP MANAGEMENT SYSTEMS ON GROWTH AND PRODUCTIVITY OF THREE PUMPKIN VARIETIES

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Abstract: Yield, fruit size and shape are important deterministic characteristics for marketing pumpkin locally and internationally. An evaluation of new and improved varieties with export quality characteristics was conducted at the UFS on a River Estate series using different crop management systems including the Ministry of Food Production, Mafas Ltd. and Caribbean Chemicals Ltd. cultivation guides. Growth and reproductive data were collected monthly, while yield and fruit quality measurements were made after eight weeks. Interaction effects of variety×system significantly affected vine diameter, number of flowers, fruit diameter and length. Stem diameter increased with time, whilst the number of flowers fluctuated across both variety and system. Pumpkin yield varied across system and variety but the differences were non-significant. CES Star produced the pumpkins with highest individual fresh weights with dimensions similar to cv. Boodles Globe but significantly different from cv. Future NP999. Cultivation system did not influence fruit quality properties. Local variety CES Star cultivated using the MFP guidelines produced significantly better pumpkin quality attributes.

Keywords: pumpkin variety, cultivation guide, fruit quality

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USING THE FIFTH QUARTER SUSTAINABLY TO SUPPORT GREEN AGRICULTURE IN THE CARIBBEAN

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Abstract: Thousands of livestock are slaughtered annually throughout the Caribbean, with little or no attention paid to the “waste” produced. Over 90% of the offal, feather, hair and animal skins from slaughterhouses are dumped or incinerated and slaughter blood is washed down into waterways. These pollute the environment, attract flies, rodents and other vermin which can transmit deadly diseases. The potential to generate revenue from the 5th quarter of livestock species is often ignored. However, the Caribbean region uses a small portion of the 5th quarter through its cultural cuisine. This includes offal/tripe, blood, head and feet, liver, lungs, kidneys, spleen and hair/feathers/hide. Still only a small fraction of these are used to produce value added products. Green agriculture innovations are imperative in the livestock sector. This paper seeks to discuss some innovations which may be implemented in the sector that utilizes the 5th quarter of the animal to generate income, provide employment and protect the environment.

Keywords: Animal processing, fifth quarter, value added products.

Proceedings of the Caribbean Food Crops Society. 51:47-49. 2015

DESIGNING INNOVATIVE AGRICULTURAL LAND SYSTEMS IN THE CARIBBEAN: APPLICATION TO GUADELOUPE

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Abstract: Farming system design needs to adopt a landscape perspective in order to better respond to sustainability issues at the regional scale. Thus, we built a method at the regional scale to design agricultural land systems accounting for field characteristics and farm diversity, current farming systems and cropping systems, and the ecological processes (e.g. pollution of water bodies) at the regional scale. This method encompasses the definition of a farm typology to approach farmer's decision processes in term of cropping system choice. This farm typology is integrated within a regional bio-economic model that produces new agricultural land systems by simulating farmers' decision processes in term of cropping system choices at plot scale, within the entire region. These new agricultural land systems are assessed with a set of indicators to provide information on their response to sustainability issues. This model coupled to the indicators are used within a scenario route to provide information on the relevance of combination of agronomic, economic, social and environmental levers to improve the contribution of agriculture to sustainable development. The method is applied in Guadeloupe for prototyping agricultural land systems that improve the response of agriculture to economic, social and environmental challenges with levers such as "agro ecological crop-gardening cropping systems", "energy crop", "changes in crop subsidies" and "availability of experienced workforce in farms". This method could be used in the Caribbean islands to help decision-makers improve the response of agriculture to sustainability challenges such as reaching food self-sufficiency, increasing employment and decreasing environmental impacts of agriculture. Coupling this approach to land use change study could provide a way of designing future sustainable islands.

Keywords: Farming system, bio-economic model, sustainable development

Introduction

Agricultural is actively involved in the provision of a wide range of ecosystem services from local to global scales. The "Farming system design" discipline has mainly been focused on designing cropping systems at field scale and farming systems at farm scale. But the design of these innovative agricultural systems has shown some limits in addressing regional and global issues. For instance at the field scale, some cropping systems may fail to reach the objectives defined at the regional scale due to the low scaling integration and the spatial heterogeneity in the region. Agronomists then need to integrate a landscape perspective for the design of new agricultural systems adapted to local contexts and addressing sustainability challenges at regional scale. We here present a method to prototype innovative agricultural land systems accounting for field characteristics and farm diversity, current farming systems and cropping systems, and the ecological processes (e.g. pollution of water bodies) at the regional scale.

Materials and methods

The method starts with a farm typology that groups farmers based on the similarity of their decision-process in term of cropping system choice. This farm typology is realized with a classification tree which allows the classification of farmers in types based on crop acreage thresholds. A regional bioeconomic model called MOSAICA has been designed in order to prototype agricultural land systems by optimizing the cropping system composition and organization on farmer's plots all over a region. This optimization at regional scale produces new agricultural land systems that are assessed with a set of regional indicators. These indicators use the information on cropping systems allocated to plots and field characteristics, which are up-scaled based on different scaling procedures, to provide an assessment of ecosystem services provision through a score. Furthermore, the variability of response of cropping systems to sustainability issues is assessed by spatializing these indicators. The farm typology, the bioeconomic model and the regional indicators are used through a scenario route in order to test the impact of several agronomic, economic, social and environmental levers of change on the organization of cropping systems at the regional scale and the consequences of these new agricultural land systems on the provision of ecosystem services. Through this framework, relevant levers are selected based on their ability to respond to a given issue and they are combined in a "Go Sustainable" scenario to improve the entire contribution of agriculture to regional sustainable development.

Results and discussion

We applied this method in Guadeloupe based on a geographical field database with 25 057 fields and 5336 farms. Biophysical and farm structure information was added to this database through geographical information system and regional statistics. The farm typology, realized from this database, is composed of eight farm types: arboriculturists, banana growers, specialized cane growers, crop-gardeners, breeders, diversified cane growers, mixed sugarcane-breeders and diversified producers (Chopin et al., 2015). The bioeconomic model MOSAICA is used with 36 activities describing local cropping systems that can be allocated on farmers' plots. The model is considered as valid since the similarity of crop areas between the initial mosaic and the simulated one at regional, sub-regional and field scales were respectively 90%, 84% and 77% and farm type similarity at farm scale was close to 81%. We then used the model in the framework and we selected several levers, that increase the contribution of agriculture to the response of several sustainability issues, that were combined in a "Go sustainable" scenario among which: "introduction of agro ecological crop-gardening cropping systems", "introduction of crop energy", "increase of subsidies for local food crops", "a deletion of subsidies for sugarcane" and "the ban of food crops on polluted soils". These levers combined increased the level food self-sufficiency by 160%, the production of biomass for energy by 10%, the overall agricultural added value by 120% and decreased the pollution of water bodies by 15% and the risk of food crop contamination by 100 % compared to the initial situation.

Conclusion

The mechanistic modeling of the evolution of agricultural land system helps integrate knowledge from the determinants of cropping system location, cropping system performance, the decision-process of farmers and impacts of farming practices at the regional scale. This method helps visualize the change in cropping system composition and organization at the regional scale and their impact on the societies in a spatially explicit way. This modeling method makes it possible to generate knowledge on the relevance of levers to improve the contribution of agricultural land systems to sustainable development of islands. The method and tools developed here are then particularly useful to help decision-makers improve the contribution of agriculture to sustainable development. Coupling this approach with land use study could help provide new land systems composed of urban, forest and agricultural use but with a wider diversity of agricultural uses associated to cropping systems in order to better assess the entire contribution of land system to sustainable development of societies. This land system architecture process to be built could help governments of islands build sustainable future islands.

Acknowledgments

The authors would like to thank all the agricultural institutions in Guadeloupe which provided geographical data and all the experts for their help in the cropping system definition phase. This research was funded by the "Région Guadeloupe" and the INRA "Environnement et Agronomie" Division.

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TOWARDS ENHANCING SUSTAINABLE AGRICULTURE IN THE CARIBBEAN IN A CHANGING CLIMATE

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Abstract: The routine use of crop models for yield optimisation is largely absent in the Caribbean, where agriculture is almost exclusively rain-fed. In this study, the Food and Agriculture Organisation of the United Nations (FAO) AquaCrop model was parameterized for sweet potato (Ipomoea batatas) for the first time. AquaCrop, is a yield response to water model developed (in 2008) by the FAO. Sweet potato has been identified as central to the Caribbean's pursuit of food and nutrition security, particularly in a changing (warmer and drier) climate. The crop is regarded as being (moderately) tolerant to drought (so ranked by the FAO), can grow on marginal lands, with relatively low inputs, and is highly adaptable to any agro-ecological conditions. The results of the study show that the overall simulation of biomass was good with deviations of less than 28% for four out of six simulations and season-long performance of the model was commendable. Yield simulation, though challenging, were also good. Simulations were also done under two future climates, even in the absence of long-term records of weather parameters to facilitate downscaling of climate projections. Warmer and drier conditions resulted in earlier maturity, declines in biomass and yield; while cooler and wetter conditions favoured production, but suggested a longer maturity period. Yield and biomass declines were reduced and subsequently reversed under the future climates (in both treatments) when the effect of elevated CO_2 was factored in. The study had laid a foundation for enhancing sustainable agriculture by optimizing crop production with improved resources management especially for water conservation and more effective use of inorganic inputs. Taken collectively, the conservation of water and reduction of harmful farm run-off have the potential to enhance the contribution of sustainable agriculture of the green revolution in the Caribbean.

Keywords: AquaCrop model, FAO, climate, sustainable agriculture

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A FEASIBILITY STUDY FOR A SECOND LIFE OF RICE HUSK IN SURINAME: POTENTIALS FOR RICE HUSK WASTE MANAGEMENT AND VALUE ADDED RICE PRODUCTION

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Abstract: In Suriname paddy is known to be an important commodity. However, the disposal of rice husk (RH) is a very big waste problem for the rice producers in district Nickerie, Suriname. It is being burnt or dumped in open fields, creating environmental and health problems. Previous studies have shown that rice husk has the potential for utilization, due to its composition. There are numerous applications or uses in several sectors. Countries such as Brazil, Thailand and India utilize rice husk to add value to their rice production, while reducing the production costs in order to create a more beneficial and profitable industry. Therefore, this study was carried out to explore the second life possibilities of rice husk and to which extent these possibilities can be realized in Suriname with the intention to add value to our rice production industry and at the same time contributing in solving the environmental problem. This study shows various potential applications to utilize rice husk locally such as the use of rice husk as fuel or electricity generation for the local Energy Company; furthermore, the utilization of rice husk in combination with some waste material as fertilizer in rice fields or for agricultural use. A systematic approach and feasible plan to use this material can solve this waste problem in the rice sector and give birth to a new industrial sector of rice husk.

Keywords: rice husk, rice production, second life, value added

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EX-ANTE EVALUATION OF INNOVATION BY QUALITY IN FOOD SECTORS AND ANALYSIS FROM AN INNOVATION SYSTEMS PERSPECTIVE

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Abstract: We focus on the conditions of emergence of innovation by quality in food sectors. We assume that food sectors can be seen as systems. The first hypothesis is that integrating the different compartments of the sector allows managing its transition towards sustainability. The second hypothesis is that innovation by quality is the vector of transition. We applied our analysis to the yam sector in Guadeloupe (French West Indies) by an ex-ante assessment of the potential for innovation by quality. The methodology combined several tools to examine consumption, production and marketing conditions of yams: focus groups, experimental economics, semi-structured interviews of farmers and market surveys. We reflected on this assessment from an innovation system perspective and pointed out the conditions of emergence of quality in food sectors. Results show that premium consumers are willing to pay for quality labels on yam, which is important from an economic point of view. This could induce farmers to engage into a quality scheme for yam production, providing adequate institutions and creating synergy within actors in the yam innovation system. These results add to the findings and guidelines of UNEP, which is moving towards a green agriculture requiring research, investment and capacity building. We made recommendations to this effect, targeting professionals from the agricultural, research and development sectors as well as policy makers in Guadelupe. As such, an increased synergy within the innovation system was enabled.

Keywords: food sector, ex-ante evaluation, quality, innovation system, conditions of emergence, yam, Guadeloupe.

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THE CONTRIBUTION OF GREEN AGRICULTURE TO GREEN ECONOMICS GREENING THE ECONOMY: A CASE FOR SUSTAINABILITY

Michel Prom, Ambassador of France to Suriname.

Introduction

Nowadays, biothechnology has great advantages such as biological production and processing activities with the partial substitution of physical and chemical technologies of biotechnology. It has immediate consequences in the fields of bioenergy and bio-based molecules in chemistry and materials. The application of sustainable development principles exceeds the contribution of biotechnology by contextualizing in food chains, energy and chemicals in favor of a systemic vision with interlaced material flow, energy and information. Resulting biomass substitution of notions, interconversion of biomass, waterfall effect in successive uses of biomass.

Green Economy a reality in a phase of growth:

Figure 1: Is Green Economy equal to Sustainable Devolopment?

Most of G7 and European countries have adopted strategies for green economy, e.g France has a production of eco-activities near 85 billions € (23% of grand total), with a turn over of 32 billions (26%), and giving employment to 447. 500 (18%) people. While, Finland has a revenue of 60 billions €, creating 300.000 jobs (13%), and with 26% of exports.

Ecoomy strategy in Europe:

Figure 2: Bio economy strategy in May 2014

Europe has adopted in 2012 a strategy for a sustainable bioeconomy to ensure green growth, which shouldgive a urnover of 2 trillions €, and employing 22 millions people (9% of employment). France is also planning to set up a strategy involving INRA in this case.

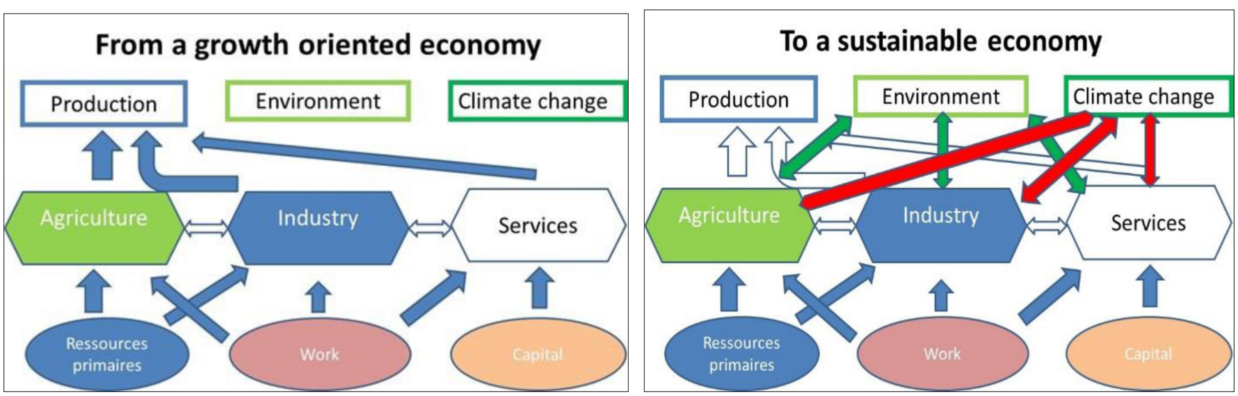

Figure 3: The change from a growth oriented ecnomy into a sustainable economy

Agriculture is not only seen as a production area but it has also impact on other aspects such as: environment, climate change. So, we should move our thinking in nit only production but also thinking about sustainable agriculture in a green economy. Taking into account the concept of agroecology in many areas and referring to the UN context, with reference to the Secretary General's report of the UNGA (August 2013), a global strategic framework of the CFS Agenda Post 2015, in reference to the ODD 2 should develop sustainable agriculture. Agroecology interest should meet the challenge of environmental sustainability and climate change. We should gobeyond the fact of a productivist vision of agriculture geared towards intensive production growth, to design a multifunctional agriculture promote a sustainable and balanced development, preserving ecosystems.

Agriculture back at the centre of economy?

During the 17th and 18th centuries, agriculture was the spill and the wealth of the nations. Starting from the 50s, the green revolution came into act and there were stages of development towards industrialisation and services. Since the 80s, we have seen that agriculture is the base of a new economy, the green economy, in the heart of a sustainable development.

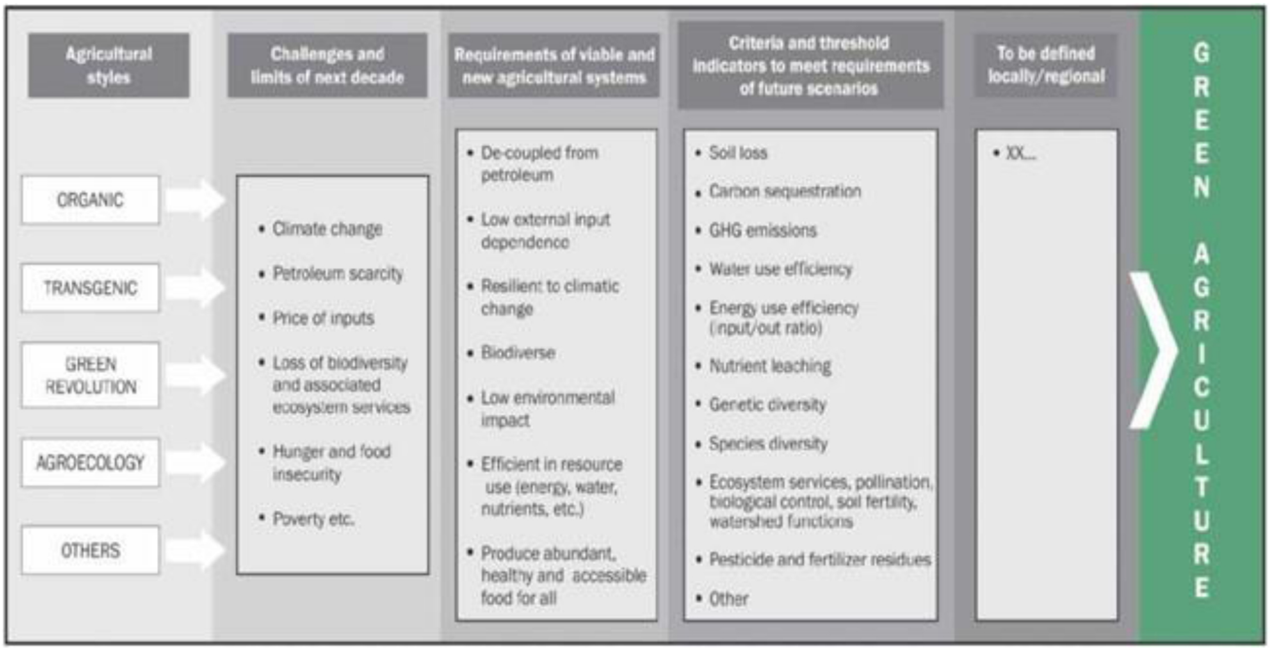

Figure 4: Challenges for a Green Agriculture

Agriculture has a challenging triple efficiency:

- Achieving food security to face the growth of the world population
- Developing sustainable economic models which preserve environment and
- Contribute to the fight against climate change

Green economy: economic growth with environmental sustainability

The production and use should be based on knowledge of the biological resources in order to provide products, processes and services to all sectors of the economy in the context of a sustainable economic system. Sustainable bioeconomy has the ultimate goal of "biologize" deep economy, using new industrial processes and products based on biological resources (e.g, plastics, building materials, etc. biological) and by changing consumer behavior.

Some examples of green production are:

- Finland: the strategy is mostly based on the resources from the forest, biomass is used in wood factory, chemical, energy, food, building sector, eco-systemic services. It is estimated that one third of the chemical industry uses « bio based » materials: vegetable oils for paints, packages, cosmetic creams, bio fuels etc.

- France: resource come from agriculture and forest mainly in comprehensive production and commercialization chains: Food, building (insulating materials), organic fertilizers for agriculture, energy, biofuels, cosmetic, etc.

But how about the Caribbean?

There is a need for international cooperation and exchanges of experiences and knowledge in:

- Innovation and research
- Holistic approach including diverse partners
- Knowledge particularly for farmers
- More human resources
- Greater adaptation of agriculture to the environment area
- Importance of small or family structures

I have noticd that during this conference a lot of topics based on the green economy will be presented and discussed, so this is a good forum to exchange experiences and knowledge.

Thank you.

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GREATER USE OF SKELETAL MEATS AND TRIMMINGS IN TRINIDAD AND TOBAGO FOR VALUE ADDED PRODUCTS

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Abstract: Hog head Cheese, Forcemeat, or Fromage de Têṭe is a form of meat jelly that originates in Europe and is made in many areas in the world. It utilizes skeletal meats and cartilaginous trimmings especially those of the pig's head, which are normally discarded by most pork consumers in Trinidad and Tobago. Skeletal meat contains high levels of collagen, which is denatured during the boiling process (hydrolyzation of collagen). As the temperature cools the protein attempts to reform its structure. This renaturing process does not reform collagen as the bonds form a new structure: gelatin; accounting for the jelly-like consistency and texture of the head cheese with the incorporation of fats responsible for the flavor absorption and retention. The cheese is seasoned and usually pickled with salt or vinegar as flavor contributors and preservative effects with respect to their antibacterial action: lowering the water activity and creating an acidic environment. This study aims at investigating the potential for a stable value added product from pigs, which meets food safety standards and can generate additional income to small farm owners, thereby contribution to food safety in the region.

Keywords: value-added, meat processing, collagen.

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USE OF AQUATIC PLANTS IN WASTEWATER MANAGEMENT

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Abstract: Constructed wetlands are excellent chemical-free system, for reducing physico-chemical parameters and faecal coliform densities. Present research work was carried from 2013 to 2014 with the objective of wastewater management using two plant species cattail (Typha domingensis) and duckweed (*Spirodela polyrhiza* L.), singly and in combination. The results indicated that parameters such as NH3+, DO, pH and turbidity, decreased in effluent from wetland containing cattails, duckweeds and both in combination. Other parameters such as EC, K, P, Cl and Na increased in effluent from one or more wetland trials. Faecal coliform reduction close to 47% was also noted. Absorption and uptake, by plants and microorganisms, appears to be the primary mechanism for nutrient removal, while parameters such as P, SO42- and Fe are removed through formation of bonds with particles in the soil. The study revealed wetlands containing both floating and emergent macrophytes play significant role in improving wastewater quality.

Keywords: Constructed wetlands, chemical-free system**,** physico-chemical parameters

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INNOVATIVE APPROACHES FOR RICE EXTENSION IN GUYANA

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Abstract: The rice industry is currently the largest agricultural industry in the country. It is the bedrock of the Guyanese rural economy accounting for 7% of GDP and 14 % of total exports in 2013.The Guyana Rice Development Board (GRDB) provides extension services for the rice farming sector. Despite the success achieved by extension in improving the productivity of farmers using the Farmers' Field School and other complimentary approaches, the use of innovative approaches and strategies to further increase their yield and livelihoods must be examined. This paper examines current approaches used in rice extension, recommends modifications of current approaches and suggests new strategies for the delivery of extension services to the rice farmers of Guyana. Current approaches include training and visiting system, study circle and the farmers' field school. It was found that the Farmers field school, demonstrations and direct contact with extension officers proved to be most successful in transferring technology to farmers. However there is scope for new approaches involving Information Communication Technology, Farmer to Farmer and market driven to be integrated into the program. It is evident that the current extension approaches achieved much success in the rice sector in Guyana however; the role of extension has evolved from one of solely a provider of services to become increasingly an appropriate mix of provider, coordinator, facilitator and regulator. Thus any new approach must not only focus transferring and disseminating appropriate technologies on good agricultural practice but must integrate strategies for farmer empowerment and small business management so that the livelihoods of the farmers will be improved.

Keywords: rice industry, Guyana Rice Development Board (GRDB), farmers' field school, extension

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RESPONSE OF CARICA PAPAYA TO PLANTING DATE AND REDUCED FERTILIZER REGIME

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Abstract: Papaya demands nutrients continuously in large amounts and use large quantities of expensive chemically formulated fertilizers. A field experiment was conducted at the University Field Station, Mt. Hope to study the effect of planting date and reduced fertilizer regime on two cultivars of papaya *(Carica papaya* L.) (cv. Red lady and Tainung No. 2) production in a River estate loam soil. The experiment comprised of four reduced fertilizer regimes, which included, agribiotics (microbes and humic acid), arborgreen (30-10-7, slow release fertilizer), urea and 12-12-17+2 (usual farmers' practice) and no fertilizer as the control. The results showed that arbogreen treated Red lady and Tainung No.2 performed significantly better than other treatments for plant height, fruit number and also postharvest storage and quality, regardless of planting date. Arborgreen treated Red lady plants were also more tolerant to the Bunchy top virus and yielded higher fruit weights than other treatments. Tainung No. 2 plants produced higher yields with the Agribiotics treatment at both planting dates but were very susceptible to the Bunchy top virus. Results demonstrate that increased yields can be obtained using more sustainable fertilizer management, while decreasing fertilizer usage from 50-100% thereby significantly increasing profits for farmers.

Key Words: Papaya, sustainable Fertilizer use

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THE CONTRIBUTION OF SOIL MANAGEMENT TO FOOD SECURITY

Gerard den Ouden, Consultant, Belgium.

Introduction

The soil formation processes comprise of geology, environmental and soil processes (see figure 1).

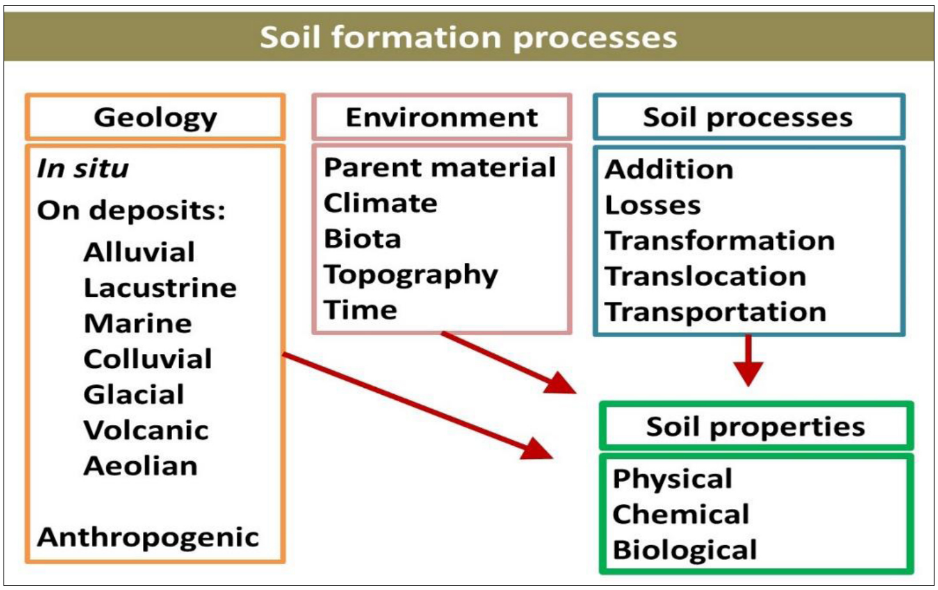

Figure 1: The soil formation processes

The main characteristics in the Caribbean are:

- Mean annual air temperature :15 – 30 °C
- Mean annual soil temperature (MAST) :15 - 22°C
- Rainfall :500 – 3,000 mm
- Soil moisture regime: =
  - Udic: semi-arid climate. Rain occurs during the growing season. Usually dry in summer.
  - Ustic: wet climate. Soils tend to be wet and irrigation of crops is not usually necessary.
- Varied soil types
- Varied land cover
- Main ecological zones: coastal regions, river valleys, humid regions, hilly slopes and marine and fresh water ecosystems.

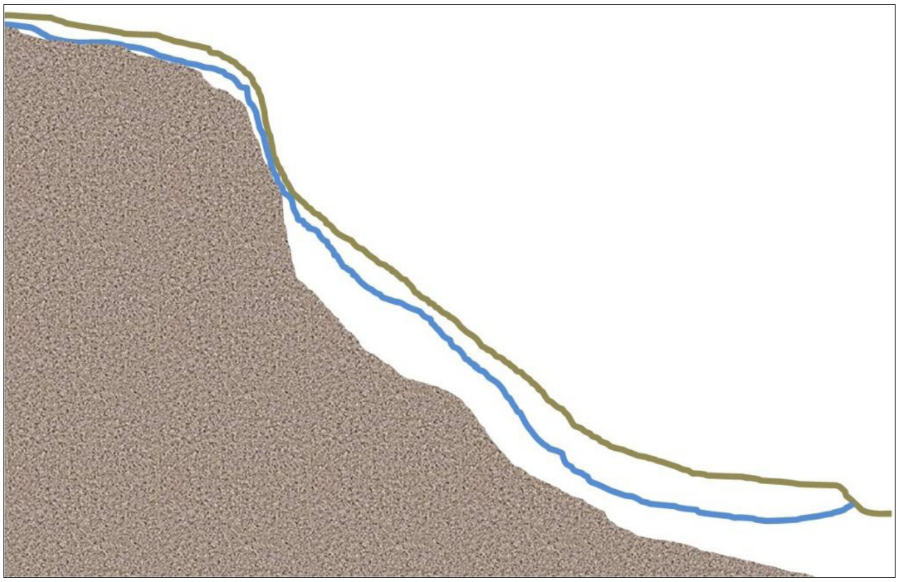
Figure 2: Landsurface catena

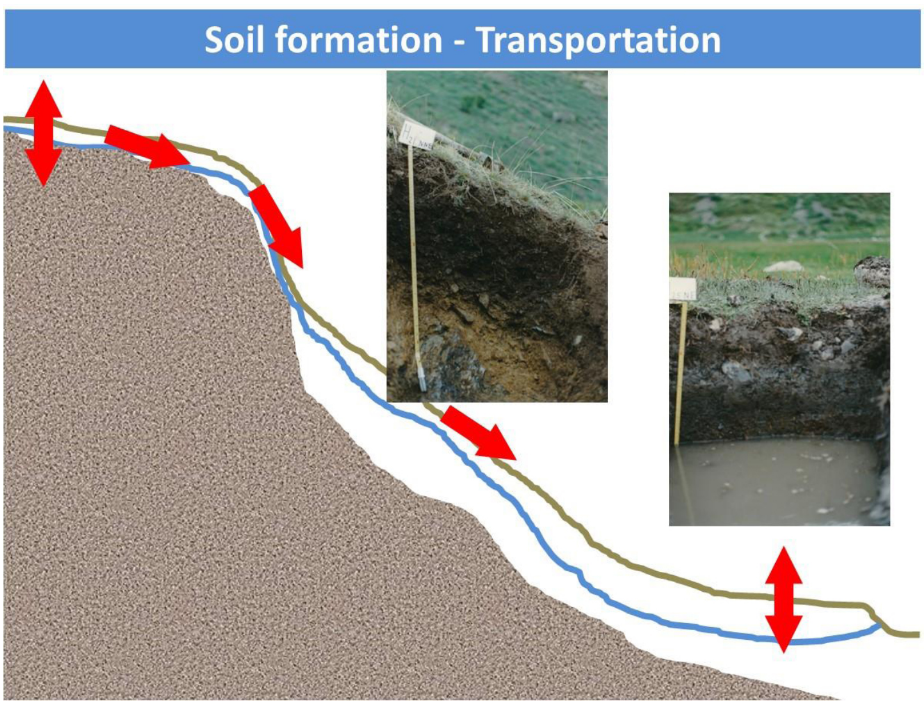

Figure 3: Soil formation

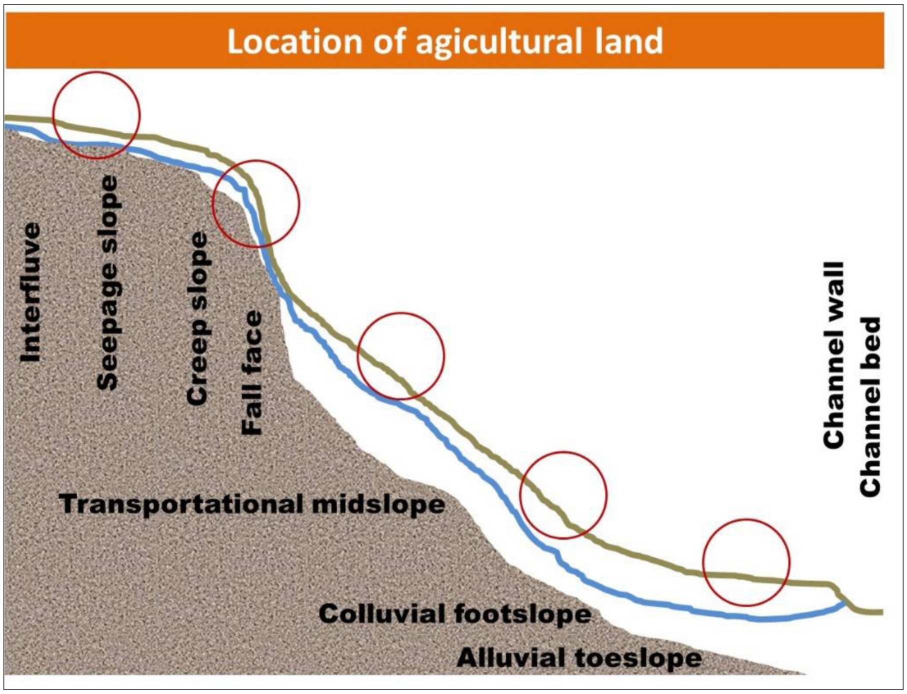

Figure 4: Location of agicultural land
Soil quality = soil health

The continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and human beings. And with respect to food security, to support both the agricultural production and the provision of other ecosystem services. Figure 5 gives an overview of food los or wated per region and continent.

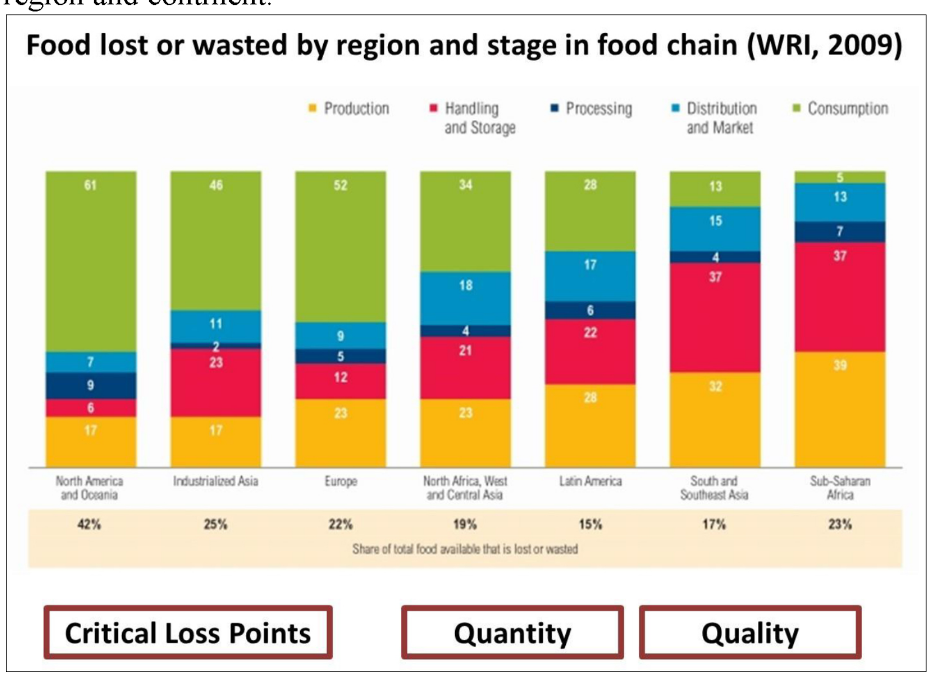

Figure 6: Comparison of food lost or waste per continent (WRI, 2009).

Soil services: Healthy soil give us clean air water, crops forests, grazing lands and landscapes.
Soil functions in various way such as:

- Regulating water: Control of water and dissolved solutes flow over the land or into and through the soil.
- Sustaining plant and animal life.
- Filtering and buffering potential pollutants - Soil minerals and microbes filter, buffer, degrade, immobilise, and detoxify (in)organic materials.
- Cycling nutrients: C, N, P + many other nutrients are stored, transformed, and cycled in the soil.
- Physical stability and support: Plant roots; Human structures; Protection for archeological treasures.

Soil is an ecosystem or environmental service: **"Soil as a natural resource is essential for meeting the food, fodder, vegetable fibre, fuel and water requirements of a rapidly growing human population"**

The negative externalities of or in soil are:

- from industries, households and traffic to agriculture
- from agricultural land to the environment (remnants of fertilisers and pesticides, ash and smoke from burning practices).

What are the problems which soil has to deal with?

- Soil pollution (Impact on public health, animal health, one health, canopy cover, soil fauna)
- Physical erosion (natural - rain, wind, flooding, earthquake; human induced – exploitation)
- Biological and Chemical erosion (overexploitation, depletion of nutrients)
- Negligence and ignorance in soil + water management (sewage, trash, dumping of waste, erosion)
- Exploitation (surface and subsurface mining)
- Soil-borne diseases
- Land use changes (peri-urban agriculture, deforestation), overexploitation of natural resources, climate change and social inequalities, but also mismanagement are the main causes of land degradation
- Political diversity (non-continuous policies).

(Some examples: goldmining in Suriname, waste landfill, flooding in Guyana in 2005, deforestation in Haiti).

The challenges for us are:

- To reduce soil degradation
- Look at the impact of Climate change: "Climate-smart agriculture practices can and are reducing emissions in food production systems as well as increase farmers' resilience to climatic changes and protect food security."
- Population growth
- Economic growth

- Agricultural dynamics: "Changes in crop growing systems by using climate-adapted species which are still of interest to the market are needed to ensure both soil health and rural economy."

How to sustain the extending ecosystem services of soil?
There are several ways to sustain the ecosystem services:

- Zero-tillage or low-tillage agriculture (minimum soil disturbance, therefore preserving carbon stocks)
- Intercropping with nitrogen-fixing plants; Agroforestry
- Planting more cover crops, like shelter crops or other vegetation, increases biomass that nourishes the soil.
- Crop rotation and fallow
- Mulching
- Low input agriculture (pesticidal plants, mechanization reduction)
- Incorporation of biowaste, other organic soil additives
- Biochar ('Terra Preta')
- Avoid slash-and-burn
- Water harvesting and groundwater recharge
- Soil conservation (terracing, …)

This need a cooperation between several stakeholders (farmers, reserachers, policy makers, ectension workers) for achieving healthy soil (see figures 7 and 8).

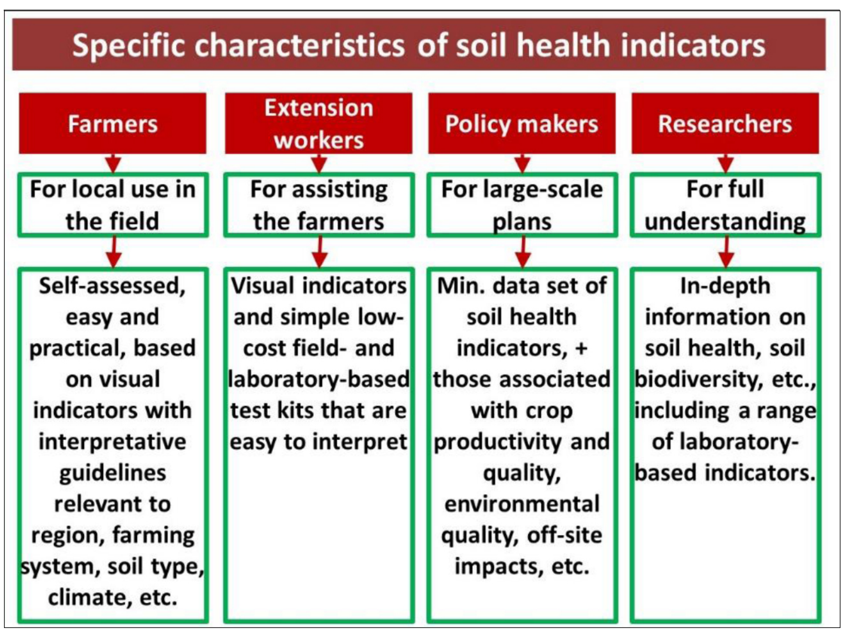

Figure 7: Indicators of a healthy soil.

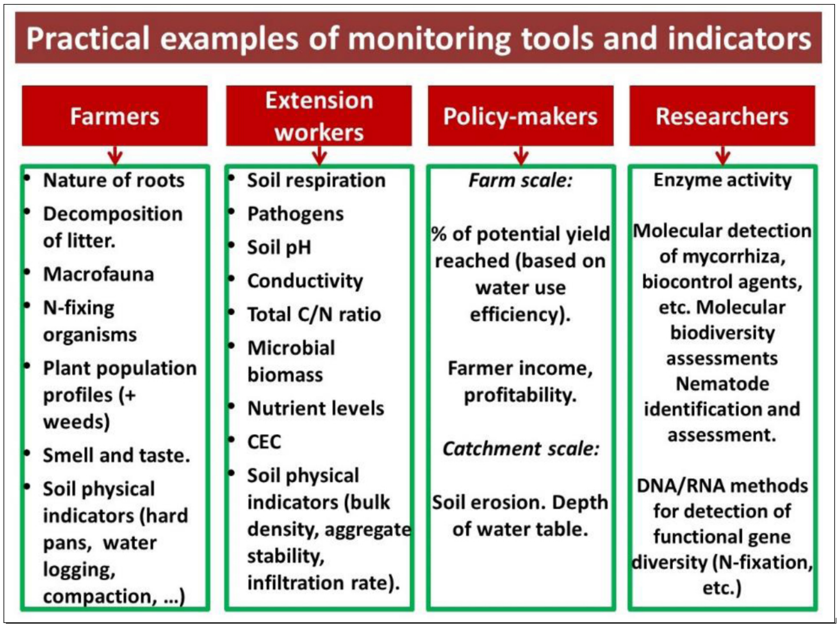

Figure 8: Collaborators and monitoring tools for a healthy soil.

We should take a holistic approach in the following aspects:

- Conduct research on the variability of soils and its potentials, to make models (e.g. FAO AquaCrop Model; biophysical).
- Conduct a mapping on Caribbean-specific soil characteristics, incl. land characteristics (Land Utilization Types, agro-ecological zones), soil parameters per LUT (morphology, fertility, vegetation communities, indicator species, drainage index, soil biodiversity index with a relation to target and threshold levels) and general environmental parameters (rainfall and weather parameters,…).
- Ethnopedology.
- Land property: soil audits and soil passports with a focus on use (industrial, residential, agricultural, forested land, etc., incl. past uses – large/small holding farms, secondary forest, etc.), quality (fertility, depth, drainage; tillage, soil biodiversity), environment (surrounding land use types), and hydrology (GWT, water quality and access to water sources). - GIS / GPS, land registry.
- Green marketing ('Controlled designation of origin').
- Prepare a monitoring scheme of land and soil quality (historical data, baseline data, follow-up data, interpretation to climatic + human impacts and natural hazards).
- Condust best practices in soil and water management at local scale with stakeholder events.
- Soil legislation (e.g. Soil protection laws).
- Environmental planning (soil demand, protected areas) in combination with Environmental Impact Assessments (EIA).
- Risk aversion / climate mitigation plans to ensure soil capacities:
- Fluctuation in weather patterns (less rainfall, intensified rainfall)
- Flooding risks (SIDS)
- Occurrence of natural hazards
- Increase in solar radiation (affecting plant growth)
- Increase in land pressure (population growth, economic exploitation of land)

- Pollution monitoring – alarm system; Weather forecast sytems – Internet / GSM
- Regional Caribbean Soil and Water Knowledge Centre accessible to the public at large (with links to universities, research centres, stakeholder fora, NGOs at regional and global level) to collect, study and exchange information, to promote best practices, and to provide advice. Local (or national) hubs should be introduced to liaise with local groups/persons.
- Commitment required from national / regional authorities.
- Outspoken and demonstrated initiatives towards preservation / restoration / improvement of the soil resources: Farmer Field Schools; showcasing good practices; frequent visits of extension services together with academia, NGOs, etc.; public awareness campaigns (TV, radio…); demonstration sites
- Integrated watershed management.
- Innovative natural soil additives.
- Continued dialogue between producers, traders, planners, financers, educators and consumers.
- Continued research in sustainable climate and environment-adapted agricultural systems (feasible and market-oriented).

Good soil is our health!

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THE ANTIMICROBIAL ACTIVITY OF VARIOUS SOLVENT TYPE EXTRACTS FROM SELECTIVE FRUITS AND EDIBLE PLANTS

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Abstract: As part of a research initiative to evaluate food crops for their nutritional and herbal values, the antimicrobial activity of the n-C6H14, CH2Cl2 and CH3CH2OH extract of *Brassica rapa* chinensis, Artocarpus altilis, Solanum melongena fruits and leaves of Moringa oleifera were investigated. Each plant part was subjected to selective extraction using the above solvents. Antimicrobial activity was investigated asceptically, using the Disc Diffusion Assay at a concentrations of 0.025g/ml, 0.05g/ml and 0.1g/ml against pathogens: *E. coli, S. aureus, Bacillus subtilis, K. pneumoniae* and *C. albicans* for *Brassica rapa chinensis* and *Artocarpus altilis*. Also, the combined CH3CH2OH and n-C6H14 extracts of A. altilis and Brassica rapa chinensis were investigated. The n-C6H14 and CH3CH2OH extract of Solanum melongena fruit and leaves of Moringa oleifera were tested for their antimicrobial activity at concentrations of 5%, 10% and 20% of crude extracts. The diameter of the zone of inhibition, DZOI was used as the food crop antimicrobial potency. The highest AZOI of 209.34 mm2 was induced by the CH3CH2OH extract of *Brassica rapa chinensis* against E. coli at a concentration of 0.025g/ml. The lowest AZOI of 12.56 mm2 was induced by *Brassica rapa chinensis* against *Bacillus subtilis* at a concentration of 0.025g/ml. Both the n-C6H14 and CH3CH2OH extracts of Solanum melongena fruit and Moringa oleifera leaves showed greater antibacterial activity at a higher concentration of 20% of crude extract. The order of bacteria susceptibility to *Moringa oleifera* extract being *S. aureus* > *K. pneumoniae* > *E.coli,* whereas that for *Solanum Melongena* extract being *S. aureus* > *E.coli* > *K. pneumoniae*. The area of zone of inhibition ranged from 44.15 mm2 to 53.55 mm2. Selective antimicrobial activity were observed for all four food crop extracts. Thus, the above food crops can be used as antibacterial agents in addition to their nutritional values.

Keywords: antimicrobial, *Brassica rapa chinensis, Artocarpus altilis, Solanum melongena* fruit, *Moringa oleifera* leaves, *E.coli, S .aureus, Bacillus subtilis, K. pneumoniae, C. albicans*, antimicrobial selectivity.

INTRODUCTION

Research in the design and syntheses of antimicrobials will continue to be problematic considering that bacteria and fungus developed resistance to antimicrobials over a period of time [1-7]. Antibiotic resistance has become a global concern[5-7]. This is primarily due to indiscriminate use of commercial antimicrobial drugs used for the treatment of infectious diseases. This has led to the search for new antimicrobials, both herbal and synthetic. However, synthetic drugs/medicine have several adverse side effects which are usually irreversible when administered and the cost of synthesizing drugs in most cases is an expensive endeavour [1-5]. In addition, phytochemical screening and natural products isolation can lead to novel and know natural products whose *in vitro* antimicrobial activity can be compared with that of the crude plant extract[8-9]. Guyana has a rich bio diversified flora whose organic and aqueous extract have been shown to possess potent and selective antimicrobial activity compared with standard antibiotics: penicillin, nystatin and ampicillin[10-16] etc. In addition, there is also a need to assess the medicinal values of plant used as food source. Thus, efforts should be made to intensify the production of food crops in the agro-industry that have antimicrobial properties in addition to their nutritional properties.

In search of antimicrobials that have nutritional values (neutraceuticals), the use of the solventless C_6H_{14} and CH_3CH_2OH extracts of *Solanum melongena* (Solanaceae), *Moringa oleifera (*Moringaceae), *Brassica rapa chinensis (Brassicaceae), Artocarpus altilis* (Moraceae), against human pathogenic microorganisms: *E. coli, S. aureus, K. pneumoniae and C. albicans* are reported here. Several natural products have been isolated from these plants with a wide range of medicinal activities [17-34].

MATERIALS AND METHODS

Collection of Plant material:

Fresh parts of the above plants were handpicked from a local farm on the Coast Plain of Guyana and were placed in bags. These were washed with distilled water and dried for four (4) hours. They were further air dried for one week and sent for authentication at the Centre for the Study of Biological Diversity, University of Guyana. Breadfruit and Pak choi were collected from a local farm and were subjected to aerial drying.

Procedure:

(a) Preparation of Herbal Extracts for antimicrobial assay: Solvent Extraction:

n-C_6H_{14}, and CH_3CH_2OH solvents were freshly distilled prior to use. (387 g) of *Solanum melongena* fruit and 350g of *Moringa oleifera* leaves were extracted thrice in six hundred milliliters (600 ml) of n-C_6H_{14}. The procedure was repeated using freshly distilled CH_3CH_2OH. The contents for each extraction was filtered, solvents dried over anhydrous Na_2SO_4 and removed in *vacuo*, resulting in viscous extracts whose state are shown in Table 1.0..The weighed plant parts of *Brassica rapa chinensis* (375g) and *Artocarpus altilis* (361g) were also placed in extraction jars and extracted sequentially with solvents of varying polarity: n-C_6H_{14}, and CH_3CH_2OH. After extraction, solvents were filtered and dried over anhydrous Na_2SO_4. Solvents were removed in *vacuo* resulting in viscous extracts and semi-solids, Table 1.0. Antimicrobial properties of *Solanum melogena* and *Moringa oleifa* C_2H_5OH and n-C_6H_{14} extracts were investigated in *vitro* at concentrations of 5%, 10% and 20% of extract per solvent. For *Brassica rapa chinensis* and *Artocarpus altilis*, each extract was prepared in concentrations of 0.025g/ml, 0.05g/ml and 0.1 g/ml respectively. Solutions containing varying concentration of *Solanum melongena*, *Moringa oleifera*, *Brassica rapa chinensis* and *Artocarpus altilis* extracts were subjected to antimicrobial susceptibility tests against human pathogens: *E.coli*, *S. aureus*, *K. pneumoniae* and *C. albicans*.

(b) **Antimicrobial Susceptibility Tests**:

The Disc Diffusion assay was used to evaluate the antimicrobial activity of these edible plants. This method has been previously reported [10-27]. Each disc was impregnated with the anticipated antimicrobial plant extract of *Solanum Melongena* and *Moringa oleifera* at appropriate concentrations of 5%, 10% and 20 % of n-C_6H_{14} or CH_3CH_2OH extract using a microlitre syringe.

For *Brassica rapa chinensis* and *Artocarpus altilis*, these were at concentration of 0.025mg/L, 0.5g/L and 0.1 g/L respectively. The plates were then incubated with the test organism: Bacteria at 37℃ for 24 hours. The antimicrobial compound diffuses from the disc into the medium. Following overnight incubation, the culture was examined for areas of no growth around the disc (zone of inhibition, ZOI). The diameter of the zone of inhibition, DZOI, was measured using a transparent plastic ruler. Each experiment was done in triplicates. *Ampicillin* was choosen as the reference for all bacteria species used: *E.coli*, *S. aureus* and *Klebsiella pneumonia,* whereas Nystatin was used for fungal species. The Control experiment consists of a plate of solidifying agar onto which was inoculated pure solvent with microorganism mixed in a 1:1 portion, [35-37]. Gram negative (-) *E. coli,* Gram positive (+) strains *Staphylococcus aureus* (ATCC 25923), *Klepsiella pneumoniae* and Gram positive (+) strains were obtained from the Georgetown Public Hospital, GPH and stored in a refrigerator until required.

RESULTS

Table 1.0: State and % yield of solvent type extract for *S. melongena*, *M. oleifera*, *Brassica rapa chinensis* and *Artocarpus altilis*.

Name of Plant	Weight of ground plant material (g)	Type of extract	State of Extract	Weight of Extract (g)	% yield of Extract
Solanum melongena	387 g	n-C_6H_{14}	Black viscous extract	3.6	0.9
Solanum melongena	387g	CH_3CH_2OH	Green Viscous Extract	4.1	1.1
Moringa oleifera	350g	n-C_6H_{14}	Green semi viscous Extract	3.7	1.1
Moringa oleifera	361g	CH_3CH_2OH	Green Viscous Extract	4.5	1.2
Brassica rapa Chinensis	375g	n-C_6H_{14}	Green viscous solid	2.5	0.7
Brassica rapa Chinensis	375g	CH_2Cl_2	Light green	0.7	0.2
Brassica rapa Chinensis	375g	CH_3CH_2OH	Dark green	21.9	5.9
Altocarpus altilis	361g	n-C_6H_{14}	Off-White yellow	2.5	0.69
	361g	CH_2Cl_2	Green	1.4	0.39
	361g	CH_3CH_2OH	Viscous light brown	22.5	6.23

Table 2.0: TLC profile for *Solanum Melongena*, *Moringa oleifera*, *Brassica rapa chinensis* and *Artocarpus altilis*.

Solvent Extract	*Solanum melongena* *Rf*	*Moringa oleifera* *Rf*	*Brassica rapa Chinensis* R_f	*Altocarpus altilis* R_f
CH_3CH_2OH	0.21, 0.35, 0.56, 0.61	0.35, 0.41, 0.61, 0.75	0.8, 1.88	0.8, 0.6
C_6H_{12}	0.35, 0.5, 0.75, 0.81	0.25, 0.41, 0.49, 0.61	0.32, 0.44,0.88,0.96	0.30, 0.51, 0.63

R_f: Retention factor

Table 3.0: Mean, Standard Deviation and Area of Zone of Inhibition for the n-C_6H_{14} and CH_3CH_2OH extract of *Solanum Melongena* and *Moringa oleifera*.

Sample	Pathogenic Microorganism	Concentration (%)	Mean Diameter	Mean Diameter with Standard deviation	Area of Zone of Inhibition (mm^2)
***Solanum melogena* Hexane**	*E.coli*	5	4.43	4.43 ±3.85	15.04
		10	4.46	4.46 ± 2.97	15.65
		20	7.03	7.03 ± 0.25	38.79
	S. aureus	5	6.77	6.77 ± 1.04	35.87
		10	7.1	7.1 ± 0.22	39.57
		20	5.03	5.03 ± 2.53	19.86
	Klebsiella pneumoniae	5	2.33	2.33 ± 1.04	4.26
		10	7.97	7.97 ± 3.87	48.99
		20	7.17	7.17 ± 0.25	40.24
***Solanum melongena* Ethanol**	*E.coli*	5	7.2	7.2 ± 0.71	40.69
		10	7.43	7.43 ± 0.30	43.33
		20	7.63	7.63 ±0.42	45.7
	S.aureus	5	7.87	7.87 ± 0.32	48.49
		10	7.73	7.73 ± 0.64	46.9

		20	8.27	8.27 ± 0.21	53.55
	Klebsiella spp	5	7.03	7.03 ± 0.11	38.79
		10	7.53	7.53 ± 0.32	44.51
		20	7.5	7.5 ±0.17	44.15
***Moringa oleifera* Hexane**	*E.coli*	5	4.4	4.4 ±3.81	15.19
		10	7	7 ±0.2	38.46
		20	7.06	7.06 ±0.11	39.12
	S.aureus	5	4.66	4.66 ±4.07	17.04
		10	7.4	7.4 ±0.52	42.98
		20	7.53	7.53 ±0.49	44.51
	klebsiella pneumoniae	5	7.33	7.33 ± 0.28	42.17
		10	7.26	7.26 ± 0.20	41.37
		20	4.86	4.86 ± 4.23	18.54
***Moringa oleifera* Ethanol**	*E.coli*	5	6.73	6.73 ±0.25	33.55
		10	4.76	4.76 ± 4.12	17.78
		20	7.73	7.73 ± 0.11	46.9
	S.aureus	5	5	5 ± 4.35	38.46
		10	8.1	8.1 ±0.79	51.5
		20	8.1	8.1 ±0	51.5
	Klebsiella pneumoniae	5	6.93	6.93 ±0.05	37.69
		10	7.33	7.33 ±0.05	42.17
		20	7.93	7.93 ±0.11	49.36

Table 4.0.

Plant Extracts	Tested Microorganism	Diameter of DZOI	Mean Diameter of ZOI	Area of ZOI
Hexane extract of *Brassica rapa chinensis* at low concentration (0.01 g/ml)	*E. coli*	10mm, 9mm,14mm	11± 2.65	94.9
	S. aureus	13mm, 14mm, 8mm	11.67± 3.22	106.9
	Bacillus subtilis	8mm, 6mm, 6mm	6.67 ± 1.16	34.9
	C. albicans	18mm, 8mm, 11mm	12.33 ± 5.13	119.3
Hexane extract of *Brassica rapa chinensis* at high concentration 0.1g/ml	*E. coli*	No Inhibition		0
	S. aureus	8mm, 6mm, 0	7 ± 4.16	38.5
	Bacillus subtilis	No Inhibition		0
	C. albicans	11mm, 10mm, 8mm	9.67 ± 1.53	73.4

Table 5.0. Antimicrobial activity of n-C_6H_{14} extract of *A. altilis* at low and high concentration.

Plant Extracts	Tested Microorganism	Diameter of ZOI	Mean Diameter of ZOI	AZOI
Hexane extract of *A. altilis* at low concentration (0.01g/ml)	*E. coli*	No Inhibition	0	0
	S. aureus	No Inhibition	0	0
	Bacillus subtilis	No Inhibition	0	0
	C. albicans	No Inhibition	0	0
Hexane extract of *A. altilis* at high concentration (0.1 g/ml)	*E. coli*	No Inhibition	0	0
	S. aureus	No Inhibition	0	0
	Bacillus subtilis	12mm, 10mm, 10mm	10.67 ± 1.16	89.2
	C. albicans	No Inhibition	0	0

Table 6.0. Antimicrobial activity of CH_3CH_2OH extract of *Brassica rapa chinensis* at low and high concentration.

Plant Extracts	Tested Microorganism	Diameter of ZOI	Mean Diameter of ZOI	Area of ZOI (mm^2)
Ethanol extract of *Brassica rapa chinensis* at low concentration 0.01g/ml	*E. coli*	17mm, 17mm, 15mm	16.33 ± 2.7	209.3
	S. aureus	9mm, 17mm, 15mm	13.67 ± 3.73	146.7
	Bacillus subtilis	7mm, 5mm, 0	4 ± 3.61	12.6

	C. albicans	16mm, 15mm, 11mm	14 ± 2.6	153.9
Ethanol extract of *Brassica rapa chinensis* at high concentration, 0.1g/ml	*E. coli*	9mm, 8mm, 7mm	8 ± 1	50.2
	S. aureus	15mm, 13mm, 9mm	12.33 ± 3.05	119.3
	Bacillus subtilis	5mm, 9mm, 15mm	9.67± 5.03	73.4
	C. albicans	15mm, 14mm 9mm	12.67± 3.27	126.0

Table 7.0 Antimicrobial activity of CH_3CH_2OH extract of *A. altilis* at low and high concentration

Plant Extracts	Tested Microorganism	Diameter of ZOI	Mean Diamter ZOI	Area of ZOI
Ethanol extract of *A. altilis* at low concentration 0.01g/ml	*E. coli*	9mm, 8mm, 9mm	8.67 ± 0.6	59.00
	S. aureus	13mm, 11mm, 9mm	11 ± 2	94.9
	Bacillus subtilis	9mm, 8mm, 6mm	7.66 ± 1.5	46.7
	C. albicans	No Inhibition	0	0
Ethanol extract of *A. altilis* at high concentration 0.1g/ml	*E. coli*	No Inhibition	0	0
	S. aureus *Bacillus subtilis*	No Inhibition No Inhibition	0	0
	C. albicans	No Inhibition	0	0

Graphs:

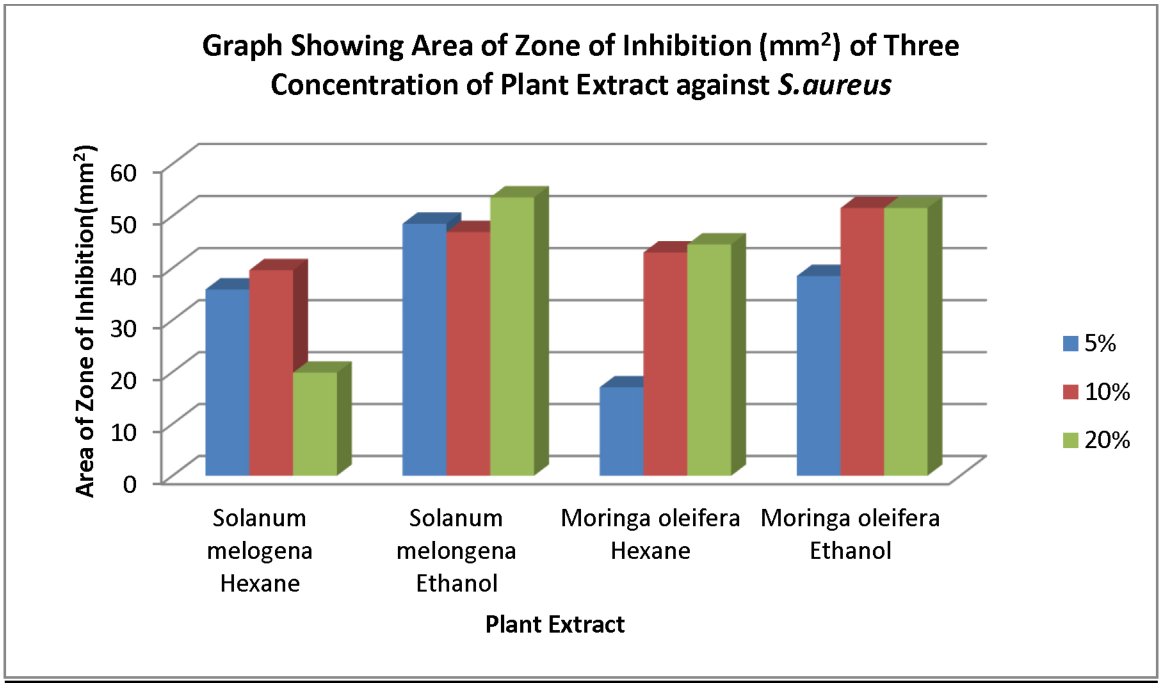

Fig. 1.0. Area of Zone of Inhibition (mm^2) of plant extracts against *S. aureus* at concentration of 5, 10 and 20%

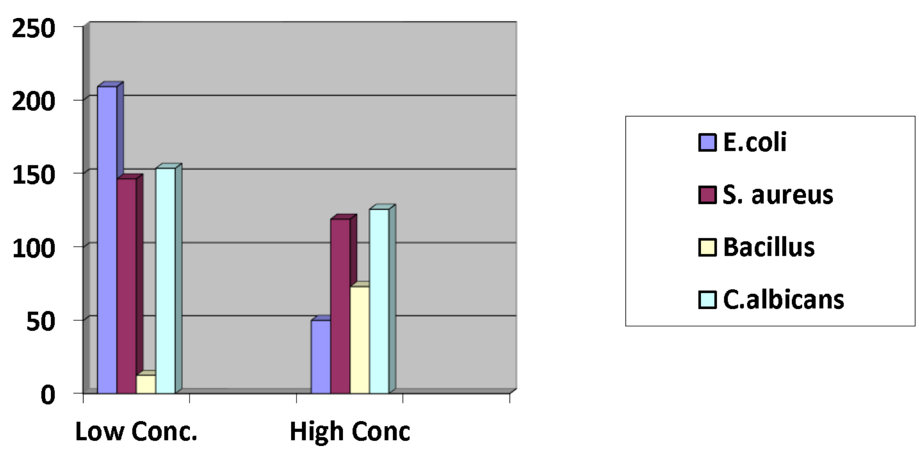

Fig. 2.0. Antimicrobial activity of CH_3CH_2OH extract of *Brassica rapa chinensis* at a concentration of 0.01g/ml, 0.05g/ml and 0.1 g/ml.

DISCUSSION

The percentage yield (%) of the solvent type extract follows the sequence: $CH_3CH_2OH > n\text{-}C_6H_{14}$ in accordance with solvent increasing polarity. These range from 0.2 to 6.23 % and are generally low yielding. TLC analysis of the CH_3CH_2OH and $n\text{-}C_6H_{14}$ extract of all four plant parts are shown in Table 2.0. Each spot is probably due to a pure phytochemical constituent.

The area of zone of inhibition, AZOI was used as an indicator of the plant's antimicrobial properties. Larger the diameter of zone of inhibition, DZOI, greater is the plant's antimicrobial activities. A comparison of the effect of the various solvent type extracts against the three human pathogenic microorganisms at three different concentrations can be discussed. In general, there seem to be an increase in the plant's extract antimicrobial activity as the concentration of the extract is increased. For example, *Solanum melongena* C_2H_5OH extract induces area of zone of inhibition (AZOI) of 40.69, 43.33 and 45.7 mm^2 against *E.coli* as the concentration of the plant extract increased from 5% to 20%. However, there were exceptions to the above general increase in bacterial activity. For example, *Solanum melogena* n-C_6H_{14} extract showed an increase in antimicrobial activity of 39.57 mm^2 at 10% concentration against *S.aureus,* followed by a decrease of 19.86 mm^2 at the 20% concentration. *Moringa oleifera* C_2H_5OH extract also showed a decreased in antimicrobial activity followed by an increase against *K. pneumoniae*. Against *E.coli,* value of 33.35 mm^2, 17.78 mm^2 and 46.0 mm^2 was obtained at the respective concentrations of 5, 10 and 20 % of extract. Of significance, there was a decrease in the area of zone of inhibition, AZOI for *Moringa oleifera* hexane extract against *K. pneumoniae* species at all three concentrations. Area of zone of inhibition of 42.17 mm^2, 41.37 mm^2 and 18.54 mm^2 were obtained against *K. pneumoniae* at respective concentrations of 5, 10 and 20% of extract. The highest area of zone of inhibition, AZOI of 53.55 mm^2 was induced by *Solanum melogena* C_2H_5OH extract against *S. aureus* at 20% concentration of extract. The smallest area of zone of inhibition, AZOI of 15.04 mm^2 was induced by *Solanum melogena* n-C_6H_{14} extract against *E. coli,* where values of 15.04 mm^2, 15.65 mm^2 and 38.79 mm^2 were registered at the respective concentration.

The C_2H_5OH extract of either plant seems to be more antimicrobial than the n-C_6H_{14} extract, suggesting greater localisation of plant antimicrobial natural products agents. For example, *Solanum melogena* n-C_6H_{14} extract induces area of zone of inhibition, AZOI of 35.87 mm^2, 39.57 mm^2 and 19.86 mm^2 against *S. aureus*. However, *Solanum melogena* CH_3CH_2OH extract induced area of zone of inhibition of 48.49 mm^2, 46.9 mm^2 and 53.53 mm^2 against *S. aureus* at concentration of 5%, 10% and 20% concentration respectively.

Graph 1, shows the area of AZOI (mm^2) at 5%, 10%, & 20% concentrations of both plant extracts against colonies of *S.aureus*. From the graph, the n-C_6H_{14} extract of *Moringa oleifera* is more antimicrobial than that of *Solanum melogena against S. aureus*. Values of 44.51 mm^2 and 19.86 mm^2 were observed respectively. However, *Solanum Melongena* C_2H_5OH *extract is more antimicrobial against S.aureus than Moringa's* C_2H_5OH extract at the 20% concentration. Values of 53.55 mm^2 and 51.5 mm^2 were observed respectively.

Antimicrobial activity of *Brassica rapa chenensis* and *A. altilis* at a concentration of (0.025g/ml, 0.5g/ml and 0.1g/ml, were investigated using the Disc diffusion assays under asceptic conditions. It was found that the n-C_6H_{12} extract of *Brassica rapa chinensis* was significantly more antimicrobial than that of *A. altilis* at both high and low concentration, Table 5.0 and Table 6.0. For example, the n-C_6H_{12} extract of *Brassica rapa chinensis* is antimicrobial against all pathogens with the exception against *E. coli* and *Bacillus subtilis* at a concentration of 0.1g/ml. AZOI ranging from 34.92 to 119.34 mm^2. Negligible AZOI was obtained against all pathogens at both concentrations for *A. altilis*. For *A. altilis*, only the n-C_6H_{14} extract at high concentration was antimicrobial against *Bacillus subtilis*. The AZOI being 89.2 mm^2. The others show zero AZOI. Fig. 2.0 shows the disc diffusion assay for the hexane extract of *Artocarpus altilis* against human pathogens.

The antimicrobial activity of the CH_3CH_2OH extract of *Brassica rapa chinensis* was investigated at a concentration of 0.01g/ml, 0.05g/ml and 0.1 g/ml with AZOI, ranging from 12.56 mm^2 to 209.34 mm^2. The highest AZOI of 209.34 mm^2 was noted for the *Brassica rapa chinensis* extract against *E.coli* at a concentration of 0.01g/ml, whereas the lowest of 12.56 mm^2 was induced by *Brassica rapa chinensis* against *Bacillus subtilis* at a concentration of 0.01g/ml. Interestingly, the ethanol extract of *A. altilis* at a concentration of 0.1g/ml was microbial in nature, as zero ZOI was induced. However, the CH_3CH_2OH extract of *A. altilis* at a low concentration induced a maximum AZOI of 94.99 mm^2 against *S. aureus* and a minimum AZOI of 46.7 mm^2 against *Bacillus* subtilis. Fig. 10.0 and Fig 11.0 shows the antimicrobial profile of *Brassica rapa chinensis* and *Artocarpus altilis* at a concentration of 0.01g/ml, 0.05g/ml and 0.1g/ml respectively.

Antimicrobial selectivity was observed for all of the extracts against human pathogens. For example, the n-C_6H_{14} extract of *Brassica rapa chinensis* showed a high degree of inhibition against *C. albicans* (AZOI, 119.34 mm^2) than against *Bacillus subtilis* (AZOI, 34.92 mm^2) at a concentration of 0.01g/ml. Likewise the CH_2Cl_2 extract of *A. altilis* at a concentration of 0.01g/ml showed inhibition of 59.0 mm^2 against *Bacillus subtilis*, but zero AZOI against *E. coli*, *S. aureus* and *C. albicans*. The CH_2Cl_2 extract of *A. altilis* at a concentration of 0.1g/ml registered a value of 54.1 mm^2 against *S.aureus* but zero AZOI against *E.coli*, *Bacillus subtilis* and *C. albicans.*

Further antimicrobial selectivity is seen for the CH_3CH_2OH extract of *Brassica rapa chinensis* at a concentration of 0.01g/ml against *E. coli* and *Bacillus subtilis*. For the former, AZOI of 209.37 mm^2 is noted, whereas for the latter, AZOI of 12.56 mm^2 was registered. Again for the CH_3CH_2OH extract, *A. altilis* at a concentration of 0.01g/ml showed antimicrobial selectivity against *E.coli*, *S.aureus* and *Bacillus subtilis* over *C. albicans*. For the latter, zero AZOI was observed whereas for the first three, AZOI, ranging from 46.7 mm^2 to 95.00 mm^2 were observed.

Moringa oleifera n-C_6H_{14} extract is more resistant than *S. melogena* extract against *E.coli* and *S. aureus*. *Solanum melogena* hexane extract is more resistant against *Klebsiella pneumoniae compared* to that of *Moringa oleifera* extract. For the CH_3CH_2OH extract, *Moringa oleifera* extract is more resistant against *E. coli* and *Klebsiella pneumoniae*. However, *Solanum melogena* extract is more resistant against *S. aureus*

Thus, for *Brassica rapa chinensis*, extract at low concentration showed the solvent type extract selectivity: CH_3CH_2OH > n-C_6H_{14}. For *A. altilis*, at a low concentration, the solvent type extract showed the selectivity of CH_3CH_2OH > n-C_6H_{12}. The n-C_6H_{14} extract of *Brassica rapa chinensis* should be more selective for *S.aureus, C. albicans* infection whereas the CH_3CH_2OH extract of *Brassica rapa chinensis should be more suited against E.coli and C. albicans infection.* The CH_3CH_2OH extract of *A. altilis* at low concentration should be suited for *S. aureus infection.*

Antimicrobial activity was also investigated for the positive control, Ampicillin and Nystatin against the pathogens. It's found that the area of the zone of inhibition, AZOI in several instances is less than that induced by the n-C_6H_{14} and CH_3CH_2OH extract of *Solanum melongena, Moringa oleifera, Brassica rapa chinensis and Artocarpus altilis.*

Fig. 2.0. Disc diffusion assay of *Artocarpus altilis* hexane extract against human pathogens

CONCLUSION

From this study it can be concluded that n-C_6H_{14} and CH_3CH_2OH extract of *Solanum melogena, Moringa oleifera, Brassica rapa chinensis* possess antibacterial activity as significant zone of inhibition, ZOI were observed. The area of ZOI ranging from 15.0 mm^2 to 49.0 mm^2 for the n-C_6H_{14} extract of *Solanum melogena* and *Moringa oleifera.* The CH_3CH_2OH extracts showed more potent antimicrobial properties than the n-C_6H_{14} extract with AZOI ranging from 18.0 mm^2 to 53.55 mm^2. For *Brassica rapa chinensis* and *Artocarpus altilis*, AZOI for the hexane extract range from 0.00 mm^2 to 119.3 mm^2. However, for the ethanol extract, AZOI ranges from 0.0 mm^2 to 209.3 mm^2. The n-C_6H_{14} and CH_3CH_2OH extract of *Solanum melogena, Moringa oleifera, Brassica rapa chinensis and Artocarpus altilis* also display antimicrobial selectivity, an important factor in preventing antimicrobial resistance. Thus,these fruits and vegetables can be used as potent antimicrobial agents, in addition to their nutritional status (neutraceuticals).

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ANTHRACNOSE DISEASE ON WATER YAMS IN THE LESSER ANTILLES: PREVALENCE AND SEVERITY CONTRASTS IN THREE CARIBBEAN ISLANDS

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Abstract: Anthracnose disease caused by the fungus *Colletotrichum gloeosporioides* is recurrent on Water Yams. In this study we analysed prevalence of early symptoms and severity of the disease at field level in three islands from the Lesser Antilles (Guadeloupe, Martinique, Barbados) along with field characteristics and tested whether these characteristics were associated with early symptoms and disease onset, in order to determine if components of crop conduct or landscape features may be identified as potentially correlated with greater disease risk. Our results demonstrate that early symptoms of anthracnose are uncorrelated with actual presence of *Colletotrichum*, and that outbreaks arise in a diversity of situations that are not fully resolved yet.

Keywords: Anthracnose, fungus *Colletotrichum gloeosporioides*, yams.

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GROWTH, YIELD AND POSTHARVEST QUALITY OF ELEVEN GREENHOUSE CUCUMBER CULTIVARS GROWN IN SOILLESS MEDIA

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Abstract: Cucumber is one of the most important vegetables grown in greenhouses around the world. Finding suitable and adaptable heat tolerant greenhouse varieties is a major constraint to greenhouse producers in Trinidad. A greenhouse experiment was conducted at the University Field Station, Valsayn to evaluate eleven heat tolerant (5 gynoecious and 6 parthenocarpic) varieties of cucumber (Marketmore 76, Decathlon, Kalima, Keish, Cherokee and 6 other Chinese varieties – Kayla, Long John, Nile, Groovy, Ethel and Spikey). The results of the study revealed significant differences ($p \leq 0.05$) among the varieties in terms of vine length, number of branches, leaf area, number of fruit per plant and total fruit weight per plant. The highest fruit yield per plant was obtained from the Chinese varieties, which consistently had higher yields than the other varieties. Postharvest evaluation conducted 8 days after storage at 10°C resulted in fruits maintaining their firmness and colour characteristics. There was also no significant difference among the eleven varieties during sensory evaluation. All varieties had ratings of 2.0 to 6.8, signifying poor to good taste. The Chinese varieties performed the best in this trial. The data should especially be valuable when evaluating yield, fruit length, colour and powdery mildew tolerance.

Keywords: Greenhouse, cucumber varieties, postharvest.

INTRODUCTION

Cucumber (*Cucumis sativus* L.) is a vegetable crop of the Cucurbitaceae family and a very popular crop for greenhouse producers in many areas of the world. Cucumber is one of the oldest cultivated crops, and thought to have originated in the northern sub-Himalayan plains of India. With several varieties ranging from dark to light green skin, the crispy, moisture-rich fleshed fruit may have small edible seeds concentrated near the core. It is a primary source of vitamins such as vitamin K, minerals and fibre for humans; but its caloric and nutritional value is very low (Keopraparl, 1997). Cucumber production is growing in popularity among greenhouse producers in Trinidad and Tobago, however, finding suitable varieties is a major problem. Gynoecious varieties of cucumber (100% female blossoms) usually are more productive and produce fruits with smoother skins than monoecious types, having both female and male flowers (Hochmuth, 2001; Marr, 1995; Singh et al. 2005). Parthenocarpic cucumbers are seedless because the fruit is produced without being pollinated. If this type of cucumber is planted near others, pollination will occur and seeds will form. Parthenocarpic cucumbers tend to bear fruit earlier, with a more concentrated set and better yield overall. This trial was conducted to compare the performance of locally available imported varieties sold to greenhouse producers and six new Chinese varieties.

MATERIALS AND METHODS

Eleven (11) varieties from the United States of America and China (5 gynoecious varieties and 6 parthenocarpic varieties) were selected for investigation. Cucumber seedlings were transplanted into coconut coir bags and arranged in a randomized complete block design (RCBD) with 4 replications. The experiment was conducted in a split arch, gable roof greenhouse, which was fully enclosed with insect screen at the University of the West Indies Field Station (UFS) located at Valsayn, Trinidad (10° 39' 0" N, 61° 25' 0" W) between February-April, 2015. Greenhouse temperatures varied between 0–45°C for the 3 months. The 15–20 day-old transplants with 2 to 3 true leaves were transplanted in 2 double rows in each plot, with 30-cm spacing between and within the rows and a 1-m walkway between the 2 double rows. The plants were irrigated using a micro-tube with emitters placed at each plant in the double row at a 30-cm distance. Plants were fertigated at least 12 times per day at 5 minute intervals with each plant receiving 2.5 litres of water per day. Plants were fertigated with the recommended soluble fertilizers throughout the trial, which included: calcium nitrate, 15:30:15, 4:4:40 and 10:52:10, magnesium sulphate, Fe chelate and micro-nutrient formulation. Plants were pruned weekly by removing “sucker vines” or horizontal vines throughout the growing period. The locally available varieties were hand pollinated once per week, using separate small brushes and transferring the pollen from the anther of the male flowers onto the stigma of the female flowers. There were no serious pests observed in the greenhouse throughout the growing period. However, the observed diseases were downy mildew and leaf spot, which occurred later at harvest. They were controlled using prophylactic treatments of Soyabean oil and Abamectin for insects and fungicides including *Bacillus subtilis* and copper with sulphur for the management of diseases. Cucumbers were harvested when the diameter of the fruit reached about 3 cm. Harvesting was initiated and terminated approximately 35 and 65 days after transplanting, respectively. Postharvest quality was evaluated on freshly harvested and stored fruit (after 8 days refrigerated at 25° C) and a sensory evaluation was conducted before and after storage to determine consumer preference using a hedonic scale (0–9). External colour was determined with a Minolta Chroma Meter CR-200. Measurements are presented as Lightness, Chroma Value, and Hue Angle. Firmness was determined with an Instron Series IX Automated Testing System 7. Rating scores of powdery mildew was determined by estimating the % of leaf area covered on upper leaves of cucumber. The 0–10 scale was designed to account for % leaf area covered by lesions. Data were analyzed by analysis of variance and means separation was by Duncan’s Multiple Range Test using SPSS analysis software.

Table 1. Cucumber cultivars used in the experiment

Variety	Production company	Origin
Cherokee	Agrinova Seeds Ltd.	Miami, Florida
Decathlon	Agrinova Seeds Ltd.	Miami, Florida
Marketmore 76	Johnny’s Selected Seeds	Maine, USA
Kalima	Agrinova Seeds Ltd.	Miami, Florida
Keish	Agrinova Seeds Ltd.	Miami, Florida
Spikey	RIJKZWAAN Seed Ltd.	China
Ethel	RIJKZWAAN Seed Ltd.	China
Groovy	RIJKZWAAN Seed Ltd.	China

Nile	Tianjin Deruit Seed Co. Ltd.	China
Long John	Tianjin Deruit Seed Co. Ltd.	China
Kayla	Tianjin Deruit Seed Co. Ltd.	China

RESULTS AND DISCUSSION

Cucumber yield and yield components

The total marketable yield ranged from 3.1–10.2 kg per plant (Table 2). Significant differences in the yield ($p \leq 0.05$) were observed among the varieties. Kalima had the lowest total marketable yield of all varieties at 3.1 kg per plant. Nile, Kayla and Long John, all Chinese varieties had total marketable yields of 7.9 kg or more per plant. Chinese varieties Spikey, Ethel as well as Long John, Nile and Kayla (all parthenocarpic varieties) had the shortest time to first fruit, ranging from 15.3–16.5 days after transplanting. Kayla produced the highest number of fruits per plant (39.1) while Cherokee produced the lowest (7.2).

Fruit size characteristics

There were significant differences in fruit width among the 11 varieties (mean diameter ranged from 0.72–2.4 cm). Fruit length ranged from 2.2–15.7 cm per fruit. Long John had the longest fruit (15.7 cm) followed by Nile (14.7 cm), Groovy (12.8 cm) and Kayla (10.1 cm). Smaller fruit of Cherokee could be attributed to the absence of pollinators and poor manual pollination in the greenhouse. As a result of poor pollination, fruit development was affected with Cherokee and others such as Kalima and Marketmore 76 (commonly used in open-field production).

Table 2. Cucumber variety characteristics

Variety	Days to 1st fruit	Days to 1st harvest	Fruit width (cm)	Fruit length (cm)	Avg. No. of fruits per plant	Avg. Weight (kg)	Firmness
Cherokee	18.4^{a}	26.0^{b}	0.72^{c}	2.2^{d}	7.2^{d}	3.5^{c}	189.4^{c}
Decathlon	21.3^{a}	28.5^{a}	1.6^{b}	6.8^{bc}	10.0^{c}	5.7^{b}	316.3^{b}
Marketmore 76	17.8^{a}	30.5^{a}	1.5^{b}	3.4^{d}	8.5^{d}	3.1^{c}	345.8^{b}
Kalima	18.9^{a}	27.0^{ab}	2.2^{a}	7.6^{bc}	12.7^{c}	6.6^{b}	400.4^{c}
Keish	17.5	32.0^{a}	1.5^{b}	5.0^{c}	7.5^{d}	4.3^{c}	193.6^{c}
Spikey	15.3^{b}	27.7^{ab}	2.8^{a}	9.9^{b}	32.4^{a}	6.3^{b}	176.4^{c}
Ethel	15.3^{b}	27.5^{ab}	2.2^{a}	9.1^{b}	21.6^{b}	7.5^{ab}	164.6^{c}
Groovy	17^{a}	30.0^{a}	1.6^{b}	12.8^{a}	13.4^{c}	6.8^{b}	185.5^{c}
Nile	16.1^{b}	28.7^{a}	1.3^{b}	15.7^{a}	8.5^{d}	7.9^{ab}	149.6^{c}
Long John	16.5^{b}	28.5^{a}	1.3^{b}	14.7^{a}	8.9^{d}	10.2^{a}	181.9^{c}
Kayla	16.0^{b}	27.2^{a}	2.4^{a}	10.1^{ab}	39.1^{a}	10.1^{a}	93.3^{d}

*Means within a column followed by different letters are significantly different as separated by Duncan's Multiple Range Test ($p \leq 0.05$).

Firmness

There was a significant difference between the various varieties for firmness. The firmest variety was Keish (400.4 gm/force) followed by Kalima and Decathlon (all locally available varieties).

Chinese varieties were not as firm as the locally available cucumber varieties. Sensory evaluation on these varieties however revealed that consumers preferred the firmness of Cherokee, Decathlon, Kalima, Keish and Ethel after 8 days of storage and all other varieties were considered firmer before the sensory evaluation.

Consumer Preference and Sensory Evaluation

Generally, consumers preferred Cherokee, Spikey (a pickling type variety) and Kayla (a long smooth variety) more than other varieties (Figure 1). The sensory evaluation for taste of fresh and post-storage cucumber is summarised in Figure 2. There were significant differences among the 11 varieties. All varieties had ratings of 2.0 to 6.8, signifying good to excellent taste, however, the taste scores were higher after 8 days for all varieties but Spikey. Respondents complained of bitterness in the taste of the fresh fruit. This can be attributed to the fact that cucumbers contain an organic compound, cucurbitacin which causes the bitterness. Although cucurbitacin is found mainly in vegetative parts of the plant such as the stem end and blossom end, it is more prevalent in the peel and light green area just beneath the peel. Cucumbers picked from vines growing under some type of stress, such as lack of water, are sometimes more bitter. Figure 3 shows the preference for texture for fresh and post for fruit samples.

Powdery Mildew

The locally available varieties were found to be more susceptible to powdery mildew (Table 3). Varieties with the most tolerance were the Chinese varieties such as Long John, Spikey, Ethel and Kayla.

Table 3. Powdery mildew susceptibility ratings for cucumber varieties

Variety	**Rating score***
Cherokee	33
Decathalon	26
Marketmore 76	18
Kalima	43
Keish	67
Spikey	3
Ethel	7
Groovy	9
Nile	12
Long John	3
Kayla	2

*Rating scores of powdery mildew was determined by estimating the % of leaf area covered on upper leaves of cucumber. The 0–10 scale was designed to account for % leaf area covered by lesions.

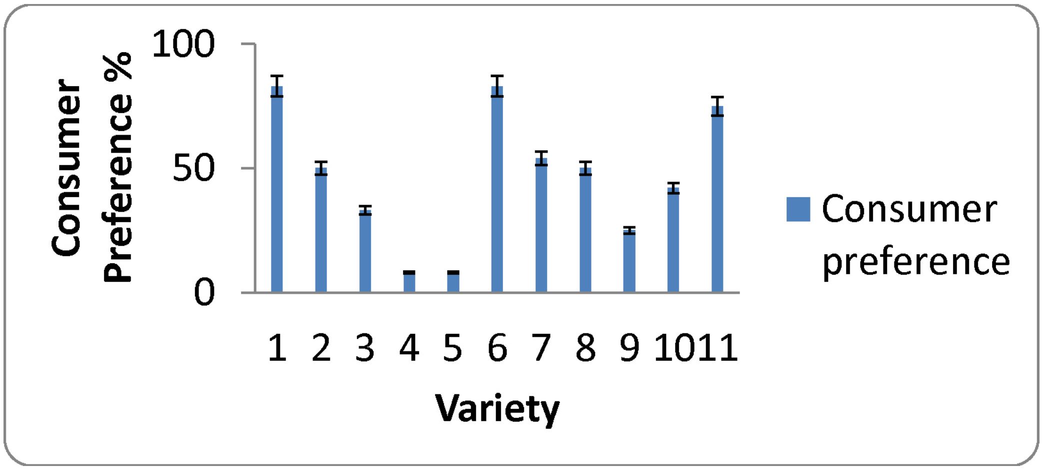

Figure 1. Overall consumer preference for market acceptability

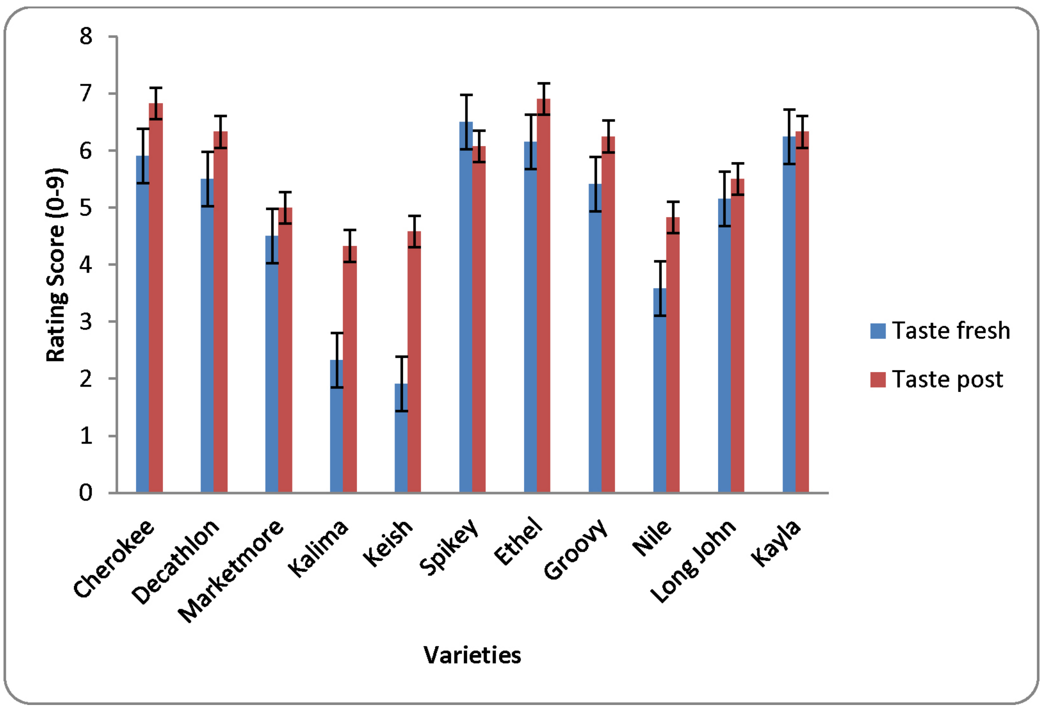

Figure 2. Taste scores for fresh and stored cucumbers

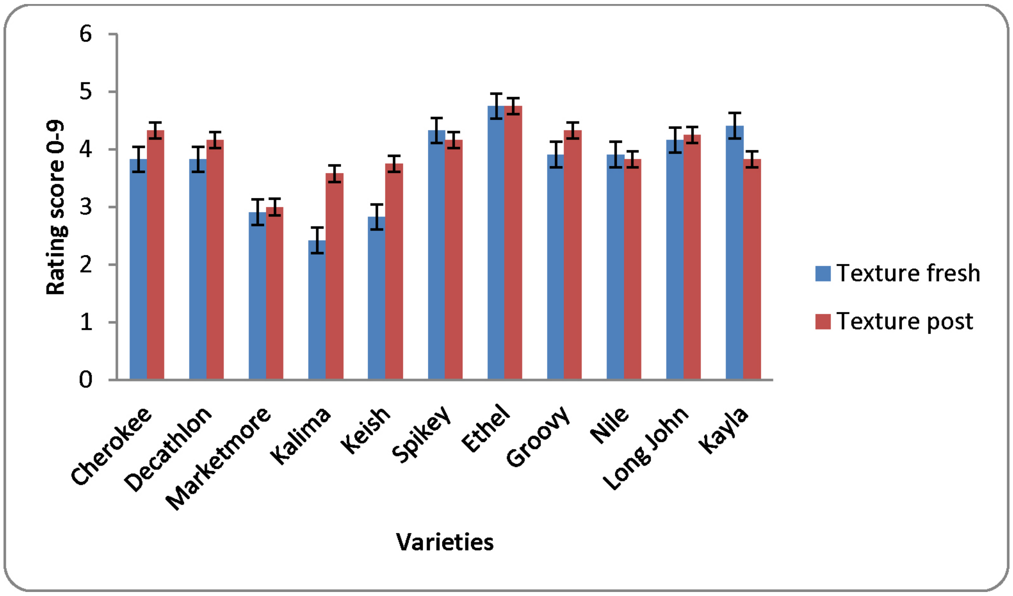

Figure 3. Texture scores for fresh and stored cucumbers

CONCLUSION

Chinese varieties Kayla and Spikey produced the highest number of fruits per plant ($p \leq 0.05$). Kayla and Nile however, produced significantly higher yields than other varieties ($p \leq 0.05$). Chinese varieties were not as firm as the locally available cucumber varieties. However, Chinese varieties were more preferred by consumers in terms of appearance, taste and texture and overall acceptability, namely Spikey and Kayla ($p \leq 0.05$). The Chinese varieties performed the best in this trial. The data presented can be used to evaluate several characteristics of greenhouse varieties. The data should especially be valuable when evaluating yield, fruit length, colour and powdery mildew tolerance in cucumber varieties.

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EFFECT OF BIOCHAR APPLICATION ON SOIL QUALITY AND PAK-CHOI (*BRASSICA RAPA* L. VAR. CHINENSIS) PRODUCTION

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Abstract: Biochar obtained from carbonization of biomass through pyrolysis is a potential soil amendment and carbon sequestration medium. Biochar in agriculture is important because both its chemical and physical properties are known to improve soil fertility. The aim of this study was to evaluate the potential use of traditionally produced charcoal (biochar) as a growth medium in raised beds on soil quality, and to evaluate its effect on plant growth. The efficiency of three levels of biochar (0, 5 and 10 ton/ha), with and without charging the biochar, on the growth of Pak-choi was investigated. The charcoal used in this research was pyrolyzed at 250°C. Results show that biochar significantly affected the total CEC, carbon content and plant production. ($p < 0.05$). In the first pak-choi field trial, the effect of biochar was not significant among the treatments, while in the second field trial significant differences among treatments were found ($p < 0.05$). The greatest biomass increase was found with 10 ton/ha biochar during the second trial. In conclusion, it can be stated that biochar has a very promising potential to be implemented as a practice to further develop sustainable agriculture production systems. In Suriname, biochar, as a sustainable practice, can also increase the production by small scale farmers. In addition, it is an option to add value to waste biomass.

Keywords: biochar, charcoal, bockchoy, pyrolyzation.

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MICROBIAL INNOVATIONS AND THEIR IMPACT ON FOOD SECURITY

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Introduction

Excessive use of chemical fertilizers and pesticides in agricultural lands over long period of time has resulted in poor soil health with combined effect on crop production and increase incidences of pests and diseases. These concerns have led to greater economic impact on farmers. Over the last few years the problems associated with food security has led to thinking in terms of organic agriculture by soil management techniques and microbial innovations. Soil microbiology influences above ground ecosystem by contributing to plant nutrition, health, soil structure and fertility. They also play a pivotal role in various biogeochemical cycles and cycling of organic compounds (Kirk *et al.,* 2004). Plant growth is improved when beneficial microbes increases nutrient availability and stimulates plant growth (Haynes and Krause, 2011). Biofertilizers, referred to the use of soil microorganisms to increase the availability and uptake of mineral nutrients for plant (Ansari, 2008), they are substance added to the soil to enhance the microorganisms, in order to increase the nutrient status. Vermicompost is one of the biofertilizers that helps to promote humification, increased microbial activity and enzyme production, which subsequently helps to increase the aggregate stability of soil particles resulting in better aeration when applied to the soil. The material has excellent structure, porosity, aeration drainage and moisture holding capacity, and helps to improve the physical, chemical and biological properties of the soil (Ansari, 2008).

The biocomposting method is made up of two phases (breakdown and buildup phase). In the breakdown phase biodegradable wastes are decomposed into smaller particles. Proteins are broken down into amino acids and finally to ammonia, nitrates and free nitrogen. Similarly, urea, uric acids and other non-protein nitrogen-containing compounds are reduced to form different plant nutrients. In the build-up phase, there is the re-synthesis of simple compounds into complex humic substances. The organisms responsible for transformation to humus are aerobic and facultative aerobic, sporing and non-sporing and nitrogen fixing bacteria of the *Azotobacter* and *Nitrosomonas* group. *Actinomycetes* also play an important role. There are two major reasons why vermicomposting is better. Waste is converted faster. Conventional composting takes weeks to months to convert organic matter to compost and are very labor intensive. By using earthworms, waste is rapidly turned into vermicompost. The vermicompost is far superior to conventional compost. The worm castings in the vermicompost have nutrients that are highly utilizable by plants and the castings have a mucous coating which allows the nutrients to "time release". Vermicompost forms fine stable granular organic matter that assist in the aeration, released mucus that are hygroscopic absorbs water and prevents water logging and improves water holding capacity. Vermicompost added to the soil releases nutrient slowly and consistently and enables the plant to absorb these nutrients more readily. Soils enriched with vermicompost provide additional substances that are not found in the chemicals (Ansari and Ismail, 2001; Kale, 1998). Biofertilizers contribute both macro and micro nutrients in amounts that are required by the plant and upon application have emphatic effect on plant growth parameters and production.

Organic waste possesses a serious environmental problem globally. This can be solved by Vermitechnology including Vermiwash and vermicompost, and also biodynamic preparation (500), which is essential component of biodynamic farming. Many researches over the years have been conducted, whereby solid waste were used and recycled to produce organic fertilizers using different technologies. In many developing countries there is a serious organic solid waste problem; preparing these organic fertilizers will be cost effective, and beneficial for farming (Ansari, 2009). The use of organic processes and materials in agriculture also helps to prevent environmental hazards, soil damage and nutrients loss due to the excess use of toxic chemical fertilizers and pesticides (Nath, *et al*., 2009).

Role of earthworm in soil fertility and microbial management

Earthworms are key to maintaining soil fertility and nutrient cycling. Earthworms process organic nutrients for the efficient growth of plants. Earthworms also contribute to the physical and chemical changes in the soil, transforming in terms of soil fertility and affect plant growth. Earthworms release casts into the soil which is enriched with beneficial microorganisms. Earthworms are classified into three ecological types. Epigeics (*Eisenia fetida, Eudrilus eugeniae*) are surface dwellers serving as efficient agents of comminuting and fragmentation of leaf litter. They are phytophagous and generally have no effect on the soil structure as they cannot dig into the soil. Anecics (*Lampito mauritii*) feed on the leaf litter mixed with the soil of the upper layers and are said to be geophytophagous. They may also produce surface casts generally depending on the bulk density of the soil. Endogeic earthworms (*Octochaetona thurstoni*) are geophagous and live within the soil deriving nutrition from the organically rich soil they ingest (Ismail, 2005).

Vermitechnology as Organic farming tool

Vermitechnology is a method of converting all the biodegradable wastes into useful product i.e. vermicompost, through the action of earthworms. Vermicompost is a sustainable bio-fertilizer regenerated from organic wastes using earthworm which contains 1.2 to 6.1% more nitrogen, 1.8 to 2.0% more phosphate and 0.5 to 0.75% more potassium compared to farm yard manure. It also contains hormones like auxins and cytokinins, enzymes, vitamins and useful microorganisms like bacteria, actinomycetes, protozoans, fungi etc (Ansari and Ismail, 2001). This process of decomposition results in the production of vermicompost. Vermicompost, or castings, is worm manure. It is considered by many in farming arena to be the very good soil improver. The nutrient content of castings is dependent on the material fed to the worms-and worms are commonly fed materials with high nutrient content (Ismail, 1997). It is the worm castings that provide these nutrients in a form that is readily available to plants. The biology of the worm’s gut facilitates the growth of fungus and bacteria that are beneficial to plant growth.

Process of Vermicomposting

Vermicomposting is a simple biotechnological process of composting, in which epigeic species of earthworms are used to enhance the process of waste conversion and produce a better end product. Vermicompost is a nutrient rich organic soil conditioner which can be applied to improve soil conditions for a wide range of soil types. The use of earthworms is very essential in this process, as the worms act for the composing of organic matter into a stable nontoxic material with good structure, which has a potentially high economic value and also act as soil conditioner for plant growth. Vermicomposting has many environmental benefits is proven to be an easy way of getting rid of garbage waste. This technique is also beneficial to the soil, and results in a lower use of synthetic fertilizers.

Vermicompsting units

Vermicomposting units can be set up on many ways. This system can be set up in a large box, a bucket, a bin, a basket and even in a pit in the soil. It is very important to keep in mind that a vermicomposting unit should be more than 1 meters in depth, but may be as long as preferred in width. It is also very important to note that such a unit is set up in the shade. Organic matter that is added to the unit should be dry to prevent an increase of temperature in the unit. The unit should be kept moist, therefore watering is very essential. The amount of materials which are layered during the building of the unit depends on the size of the unit which is set up.
The basic layering in a vermicomposting bin is as following:

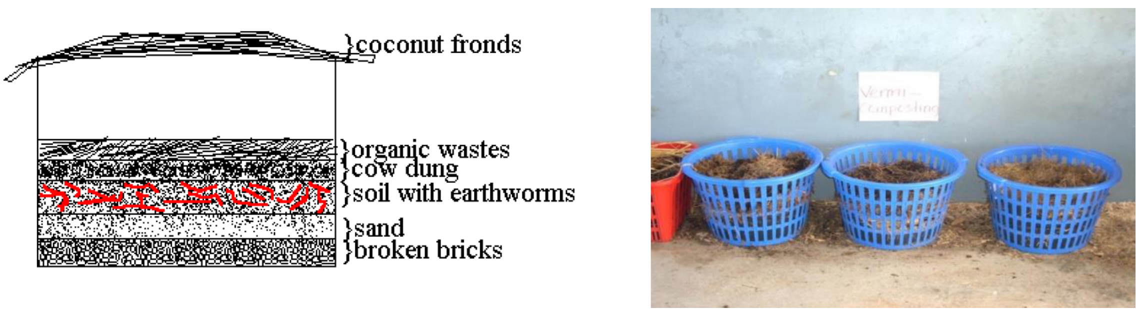

Figure 1. Layering in the vermicomposting unit

The basal layer of the vermi-bed comprises of broken bricks followed by a layer of coarse sand (10 cm thick) in-order to ensure proper drainage. A layer (10 cm) of loamy soil should be placed at the top.100 locally collected earthworms were introduced into the soil. Fresh cattle dung is scattered over the soil and then it was covered with a 10 cm layer of dried grasses. Water is sprinkled on the unit in-order to keep it moist. The dried grasses along with cattle dung is turned once a week. After 60 days, vermicompost units are regularized for the harvesting of vermicompost every 45 days. When the layering is completed, the unit should be covered with dried leaves and left for 60 days. During the period of these 60 days, organic material and cow dung should be added on a weekly basis, while watering every other day, depending on the moisture content of the material in the bin.

Harvesting of vermicompost

Vermicompost should be ready for harvesting in maximum 40-45 days. When the organic material in the unit is changed completely in structure and smells soil like, it is ready for harvest. The compost should be pressed in the hand to check on moisture content. Before harvesting, no water should be added to the unit for 3-4 days and a heap of the compost should be formed in the after harvesting. These actions will derive the earthworms in the deeper layers of the unit where the moisture content is slightly higher. The fourth day, the compost can be harvested and is ready to be used for agricultural purpose. This compost can be used directly in the soil and can be stored for 3 months if disposed well in a plastic bag.

Figure 2. Vermicompost at harvest

Benefits of vermicompost

Vermicompsot has many benefits on the soil, but has also many economic benefits which are:

1. Source of Plant Nutrients to the Soil
    a. Improves its physical structure.
    b. Enriches soil with micro-organisms (adding enzymes such as phosphatase and cellulase)
    c. Microbial activity in worm castings is 10 to 20 times higher than in the soil and organic matter that the worm ingests.
    d. Attracts deep-burrowing earthworms already present in the soil
    e. Improves water holding capacity.
2. Improving Crop Growth and Yield (Plant growth)
    a. Vermicompost plays a major role in improving growth and yield of different field crops, vegetables, and fruit crops.
    b. Enhances germination, plant growth, and crop yield
    c. Improves root growth and structure (rhizosphere)
    d. Enriches soil with micro-organisms (adding plant hormones such as auxins and gibberellic acid)
3. Economic Benefits
    a. Biowastes conversion reduces waste flow to landfills
    b. Elimination of biowastes from the waste stream reduces contamination of other recyclables collected in a single bin (a common problem in communities practicing single-stream recycling).
    c. Boost to rural economy
    d. Less wasteland formation
    e. Low capital investment and relatively simple technologies make vermicomposting practical for less-developed agricultural regions
4. Eco-Friendly Environmental factors
    a. Good quality organic soil additives enhances the water holding capacity and nutrient supplying capacity of soil and also the development of resistance in plants to pests and diseases, thereby providing a sustainable environment in the soil
    b. Wastes create no pollution, as they become valuable raw materials for enhancing soil health
    c. Helps to close the "metabolic gap" through recycling waste on-site
    d. Reduction in greenhouse gas emissions such as methane and nitric oxide (produced in landfills or incinerators when not composted or through methane harvest)

Vermiwash production

Vermiwash is one of the materials produced by Vermicomposting which is an "Eco biotechnological process that transforms energy rich and complex organic substances in to a stabilized vermicomposts" primarily through the action of earthworms but with support of other micro-organisms. Vemiwash contains the soluble nutrients that were released in the vermicomposting process (Nath, *et al*., 2009). Organic fertilizers such as Vermiwash provide a relatively cost effective and safe alternative to chemical fertilizers. According to Ansari and Sukhraj (2010), the use of chemical fertilizers, which is wide spread in many developing countries, can lead to soil damage and reduced soil health and production levels while increasing the incidence of pests and disease and environmental pollution. Vermiwash is a liquid that is obtained when water is left to flow slowely through a vermicomposting like unit. Vermiwash has fertilizing abilities and has also proven to have a pesticidal action when applied as a foliar spray. The layering of a vermiwash bin is the same as a vermicomposting unit, with the exception that this unit consists of a bucket to which a tap is attached at the lowest point to collect the vermiwash when ready. The organic matter that is added to this unit varies from ordinary grass clippings to plant material with pesticidal properties. The organic matter should be dried for 3 to 4 days to accelerate the composting action and regulate the temperature in the bin.

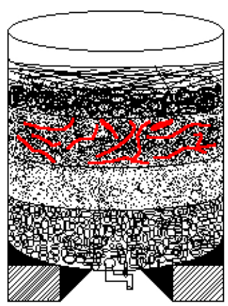

Figure 3. A detailed design of a vermiwash unit

The vermiwash unit is set up using buckets. A tap is fixed on the lower side of each bucket. The bucket is placed on a stand to facilitate collection of vermiwash. 5 cm of broken pebbles are placed at the bottom of the buckets followed by 5 cm layer of coarse sand. Water is then allowed to flow through these layers to enable the settling of the basic filter unit. A 15 cm layer of loamy soil is placed on top of the filter bed. Approximately 300 earthworms are introduced into the soil. Dried grass and cattle dung are placed on top of the soil. The vermiwash unit is left to regularize after 60 days for collection of vermiwash every day. Approximately 0.5 litre can be collected on a daily basis. After layering the different material to the bin, the unit is left for 60 days to regulate with the tap open. Organic matter and cattle dung should be added on a weekly basis as needed. The unit should be watered every other day depending on the moisture content in the bin. Access water should be left to flow through the open tap. Vermiwash will be ready to collect when the liquid that is flowing through the tap gets pale yellow in color. When the color change is seen, the tap should be closed and water should be allowed to drip through the unit overnight. The following day the tap should be opened and the vermiwash should be collected in a plastic container. The color intensity of the vermiwash will differ according to the organic material that is added to the bin. After the first collection, vermiwash can be collected on a daily basis by repeating the same process of adding water to the unit. The vermiwash that is collected can kept stored for 3 months in plastic containers. Vermiwash can be used by a dilution of 10% of the vermiwash with water and spray to the desired plant/crop.

Impact of Organic inputs in the Soil

Organic amendments like vermicompost promote humification, increased microbial activity and enzyme production, which, in turn, increase the aggregate stability of soil particles, resulting in better aeration (Tisdale and Oades, 1982; Dong *et al.*, 1983; Haynes and Swift, 1990; Perucci, 1990). Organic matter has a property of binding mineral particles like calcium, magnesium and potassium in the form of colloids of humus and clay, facilitating stable aggregates of soil particles for desired porosity to sustain plant growth (Haynes, 1986). Soil microbial biomass and enzyme activity are important indicators of soil improvement as a result of addition of organic matter (Perucci, 1990). Apart from these, earthworm castings are reported to contain plant growth promoters, such as auxins and cytokinins (Krishnamoorthy and Vajranabhaiah, 1986). Vermiwash, a liquid fertilizer produced by the action of earthworms, contains soluble plant nutrients, some organic acids, mucus and microbes, that has proved to be effective, both as a biological fertiliser (as a foliar spray) as well as a pesticide (Pramoth, 1995; Ismail, 1997; Kale, 1998).

The high content of organic matter in compost and the resultant effects of the organic matter on the humic fractions and nutrients in soil effectively increase the microbial population, activity and enzyme production, which in turn increases aggregate stability (Tisdale and Oades, 1982; Dong *et al.*, 1983; Haynes and Swift, 1990; Perucci, 1990). Humic acid and fulvic acid are important as persistent binding agents in mineral organic complexes and 52 to 92% of soil organic matter may be involved in these complexes (Edwards and Bremner, 1967; Hamblin, 1977). Increased plant litter incorporation, improved aggregation, better aeration and water relationships and the development of mull characteristics can be observed soils amended with organic inputs. These improvements in soil structure were confirmed by soil morphological studies as illustrated by Rogaar and Boswinkel, (1978). On the contrary there was reduction in organic carbon in plots treated with chemical fertilisers which may be due to negligible organic matter as input, moreover chemical inputs cause degradation of the soil structure resulting in unfavourable conditions for crop growth in an already difficult soil (Pagliai *et al.*, 1983a, b; Shipitalo and Protz, 1988).

Vermicompost, one of the important types of compost, contains earthworm casts that are reported to be higher in available nitrogen (de Vleeschauwer and Lal, 1981; Satchell, 1983) which enhance the activity and number of microorganisms (Stewart and Chaney, 1975; Satchell and Martin, 1984; Satchell *et al.*, 1984). Increase in soil nitrogen through the application of vermicompost is likely to be due to stimulation of microbial activity specifically through increase in the colonization of nitrogen fixers and actinomycetes (Kale 1998; Borken *et al.*, 2002). Much of the effect of application of compost on crop yield and productivity is derived from the plant nutrients, particularly nitrogen in composts (Woodbury, 1992; Maynard, 1993; Ozores-Hampton *et al.*, 1994). Reports indicate that adequate quantities of phosphorus and potassium were supplied by compost application to the soil (Smith, 1992; Maynard, 1993; Ozores-Hampton, *et al.*, 1994). Vermicompost, is reported to contain desired quantity of phosphorus (de Vleeschauwer and Lal, 1981; Satchell, 1983) which enhances the activity and number of microorganisms producing acid-phosphatases in the soil (Stewart and Chaney, 1975; Satchell and Martin, 1984; Satchell *et al.*, 1984). Synergistically, these specific effects appear to raise phosphorus availability in soils amended with vermicompost (Buchanan and Gliessman, 1990).

Vermicompost application in the wheat-paddy cropping system has been reported to increase crop yield (Sharma and Mittra, 1991; Ismail, 1997). This is because nutrients present in vermicompost are readily available to the plants (Ismail, 1995; Rajkhowa *et al.*, 2000). The effect of application of organic amendments like vermicompost on crop yield and production is derived from the plant nutrients, particularly nitrogen (Woodbury, 1992; Maynard, 1993; Ozores-Hampton *et al.*, 1994). Organic phosphorus solublized by microbial activity in composts like the vermicompost is more effective for plant absorption (Mishra and Banger, 1986; Singh *et al.*, 1987). The reduced cost of cultivation, less cost-benefit ratio and higher net income has been recorded in wheat and paddy cultivation through Vermitech compared with the use of chemical fertilisers along with the other economically important crops like peanut (*Archis hypogaea*) and brinjal (*Solanum melongena*) by organic methods (Ismail, 1997). Organic farming has proved to be environment friendly, sustainable and cost effective (Reganold *et al.*, 2001).

Experiments on the effect of earthworms and vermicompost on the cultivation of vegetables like tomato (*Lycopersicum esculentum*), brinjal (*Solanum melongena*) and okra (*Abelmoschus esculentus*) have yielded significant results (Ismail, 1997). Vermicompost as an organic input has been applied to grow vegetables and other crops succesfully (Ismail, 1997). Application of composts like vermicompost could contribute to increased availability of food (Ouédraogo *et al.*, 2001). This is attributed to better growth of plants and higher yield by slow release of nutrients for absorption with additional nutrients like giberellin, cytokinin and auxins, by the application of organic inputs like vermicompost in combination with vermiwash (Raviv *et al.*, 1998; Singh *et al.*, 1998; Subler *et al.*, 1998; Lalitha *et al.*, 2000). The yield of potato and the average weight of potato tubers were significantly higher in plots treated with vermicompost (Table 46). This may be attributed to increased bioavailability of phosphorus by the application of organic amendment in the form of vermicompost (Erich *et al.*, 2002).

Organic manure like vermicompost and vermiwash, when added to soil, augment crop growth and yield (Lalitha *et al.*, 2000). The yields of spinach and onion in response to diluted vermiwash along with vermicompost was highly significant which may be due to increased availability of more exchangeable nutrients in the soil by the application of vermiwash along with vermicompost (Ponomareva, 1950; Finck, 1952; Nijhawan and Kanwar, 1952; Nye, 1955; Atlavinyte and Vanagas, 1973, 1982; Czerwinski *et al.*, 1974; Watanabe, 1975; Cook *et al.*, 1980; Tiwari *et al.*, 1989). Concern about the environment and the economic and social impacts of chemical or conventional agriculture has led to many thinking groups seeking alternative practices that will make agriculture more suitable. Biodynamic farming practices and systems have shown promise in mitigating some of the detrimental effects of chemical-dependent, conventional agriculture on the environment (Reganold *et al.* 1993).

Conclusion

Soils are critical to productivity of both agriculture and natural ecosystems. Soil is an integral system, which is to be maintained through sustainability of nutrient resources. The continuous worldwide soil degradation by erosion, chemicals, acidification and physical abuse requires management in terms of soil quality. The use of organic amendments augmented with Vermitechnology could be adopted as a means for crop production and soil stability. The use of combinations of organic amendments such as vermiwash, and vermicompost can effectively bring about an improvement in soil quality, enhance microbial population and impact crop productivity thereby bringing about long term sustainability. Considering all aspects, such as studies on soil, soil health, yield of crops and cost effectiveness of Vermitechnology as a means of microbial innovation, it is concluded such technology could be applied for sustainable soil enrichment and crop productivity.

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COMPOSITION OF TRHIPS SPECIES IN TOMATO AND THEIR ECONOMIC IMPACT ON COMMERCIAL TOMATO PRODUCTION IN FLORIDA

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Abstract: Thrips (Thysanoptera: Thripidae: *Thrips* and *Frankliniella)* are insidious pest due to their tiny body size, hiding behavior and ability to transmit viral diseases to host crops. They are difficult to control even by using effective control tactics which they avoid by hiding in their habitat. Tomato is a high value crop with production cost US$ 6,000/acre. Recently, tospoviruses, Groundnut Ring Spot Virus and Tomato Chlorotic Spot Virus, vectored by thrips inflicted significant damage to commercial tomato production. Our survey in various tomato fields revealed that melon thrips (*Thrips palmi* Karny), Common blossom thrips (*Frankliniella schultzei* Tribom), western flower thrips (F. occindentalis Pergande) and onion thrips (*T. tabaci* Lindeman) are available in infected tomato fields at variable numbers being melon thrips the most abundant followed by common blossom trips, western flower thrips and onion thrips. Distribution of various thrips species along with the frequency of virus infected tomato plants and their management by using economically feasible management program comprising of chemicals of various mode of action were addressed in the present study.

Keywords: Thrips, insidious pest.

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EFFICACY OF ADSORBENTS (BENTONITE AND DIATOMACEOUS EARTH) AND TURMERIC (*CURCUMA LONGA*) TO AMELIORATE THE TOXIC EFFECTS OF AFLATOXIN IN CHICKS

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Abstract: A study was conducted to determine the efficacy of bentonite clay (BC), diatomaceous earth (DE) and turmeric powder (TUM) individually and in combination in ameliorating the toxic effects of aflatoxin B_1 (AFB_1) in broiler chicks. Two hundred and fifty Ross 308 day-old male broiler chicks were assigned to 10 dietary treatments (5 replicates of 5 chicks each) from hatch to day 21. Dietary treatments were: basal diet; basal diet plus AFB_1 (2 mg/kg) or BC (0.75%), or DE (0.75%), or TUM (200 mg/kg curcuminoids) and different combinations of AFB_1,BC, DE and TUM. Feed intake (FI), body weight gain (BWG) and feed gain (FG) of the birds fed BC or DE separately, were not different from control birds. Birds fed TUM only had similar FI and FG but lower BWG than control chicks. Aflatoxin B_1reduced ($P < 0.05$) FI, BWG, and serum concentrations of glucose, albumin, total protein, and calcium, but increased ($P<0.05$) FG and relative liver and kidney weights. Chicks fed the combination of AFB_1 and BC had similar FI and FG to control chicks. Chicks fed the combination of DE and AFB_1 had lower ($P<0.05$) FI (23.1%) and BWG (28.6%) compared with control chicks. Chicks fed the combination of TUM and AFB_1 also had decreased FI (26.2 %) and BWG (31%) compared with control chicks. Chicks fed the combination of AFB_1, BC and TUM consumed significantly ($P<0.05$) higher amounts of feed compared with chicks fed only AF, but gained ($P<0.05$) less when compared with control chicks. Chicks fed the combination of AFB_1, DE, and TUM diet had poorer growth performance than those fed AFB_1 alone. None of the combination diets reduced ($P >0.05$) the severity of liver lesions caused by AFB_1. Data indicate that BC ameliorated the effects of AFB_1, whereas DE and TUM were not effective.

Keywords: adsorbents, efficacy, toxic effects, bentonite clay, diatomaceous earth, turmeric powder, aflatoxin

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THE USE OF BIOTECHNOLOGY IN AGRICULTURE

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Abstract: Biotechnology is any technology application that uses biological systems, living organism, or derivatives to make or modify products. FAO defines biotechnology partly as a range of different molecular technology such as gene manipulation and gene transfer being used for sustainable development of agriculture, fisheries and forestry, as well as the food industry. Biotechnology is especially used in agriculture because of increased productivity, nutrition improvement, drought resistance, pests and diseases, tolerance to pesticides, to improve shelf-life, and production of pharmaceuticals (e.g. of applications). Some techniques used in biotechnology are **somatic hybridization** (fusion of genome and cytoplasm is taken place) in which the cell wall is removed; **Cybridization,** the fusion of normal protoplast of the recipient with enucleated protoplast or cytoplasm of donor. Some advantages are to overcome sexual incompatibility, transfer of traits. **Cell processing** is used for dissolving cell walls. **Tissue culture propagation** is used to manipulate cells and to grow. **Genetic engineering or recombinant DNA technology** is used to manually add new DNA to an organism to produce transgenic or GE species. During this process a particular DNA of interest is cut and put in a plasmid. **Genomics** is used to do total analysis of an organism and confers what traits are present. Everyone has been exposed to GMO because it is present in everything we eat in both developed and developing countries. The top GMO producers are USA, Brazil, Argentina, and China. Some issues to address concerning GMOs are socio-economic (who owns the right of food supplies or seed patent), acceptance, food safety issues (allergy, toxicity, need to be science based), and impacts on the environment (e.g. impacts on diversity). Some examples of GE Crops are BT-crops (contain insect resistance genes) and HT-Herbicides tolerant crops. Monsanto, Pioneer/Dupont, Syngenta, USDA research labs have a tremendous contribution. Golden rice was developed 2001; however, it has not been on the market. This rice contains high concentration of beta carotene (precursor of Vitamin D). The inventors received the Patents of humanity Awards of 2015. Procedures need to be developed to protect producers and ourselves. Examples for the Caribbean: ***Public Intellectual Property Resource for Agriculture, The African Agriculture Technology Foundation, PAU biotechnology center, and CARDI could play an important role. Organizations like CELOS should be given mandate to this.*** In Suriname we don't control our borders bringing anything agricultural products in. In the Caribbean, we are currently importers of GE knowingly or unknowingly. Plant material is traveling freely from one country to another. Our government should wake-up in protecting the product borders. There should be a way through Caricom where products need to be screened first. Empower our researchers in the region to do high tech research and we need to work on competiveness in our region.

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EFFECT OF BIOSTIMULANTS ON THE YIELD PERFORMANCE OF ORGANICALLY-GROWN OKRA CULTIVARS IN THE U.S. VIRGIN ISLANDS

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Abstract: Okra is one of the widely grown vegetables for the commercial market in the United States Virgin Islands and the rest of the Caribbean. Plant biostimulants or agricultural biostimulants include diverse substances and microorganisms that are derived from commercial marine algae extracts, enhance plant growth of fruits and vegetables. Plants of eight cultivars of okra (Abelmoschus esculentus) were treated weekly with Stimplex® (5 mL/L) liquid seaweed extract of Ascophyllum nodosum and Biozest® (100 mL/5L) crop biostimulant as foliar spray to assess their influence on yields. Half of the plants in a row (5 plants) were sprayed weekly and half of the plants (5plants) were untreated (control). Eight cultivars of okra ca. Clemson Spineless 80, Red Burgundy, Clemson Spineless, Jambalaya, Red Velvet, Annie Oakley II, Perkins Mammoth and Chant were investigated. The experimental design was a randomized complete block with 3 replications and consisted of rows spaced 3' apart and spaced 2' between the plants within a row. They were organically managed. Results showed that Biozest® treated plants of most of the cultivars responded positively. Marketable yields were higher with Biozest® treated plants of Clemson Spineless 80 (0.5%), Annie Oakley II (27.9%), Perkins Mammoth (49%), Jambalaya (41.2), Chant (16%) and Red Burgundy (60%) than with the untreated control. Higher marketable yields were obtained with Stimplex® treated plants of Jambalaya (62%), Red Burgundy (58%) and Perkins Mammoth (30%) than with the untreated control. Cultivars produced lower or non-significant yields with Clemson Spineless 80, Clemson Spineless, Red Velvet, Annie Oakley II and Chant. The results show that biostimulants may increase yields in okra. However, further research trials are needed to fully explain the effects of biostimulants in commercial production.

Keywords: Crop biostimulant, Organic, Production, Yield.

INTRODUCTION

Okra is a well-known, versatile, warm-season vegetable crop produced in the southern region of the United States. It is grown commercially in Georgia, South Carolina, Tennessee, Alabama, Texas, California, and Florida. Most southern states cultivate enough okra to satisfy local demand. There are ≈15,000 acres of land (6,000 ha) of okra produced annually in the United States. It is valued as highly nutritional and is easy to cultivate. Tender green pods are consumed as a vegetable and used as a thickening agent in soups. Well drained soil with organic matter is suitable for production of okra. This can be achieved by applying animal manures or incorporating green manure crops (Colditz and Barber, 1975). Moreover, biostimulants provide better growth and development of plants in organic management systems. There are number of varieties of okra available in the market for commercial production in an organic crop management system.

The biostimulant federation defined biostimulants as “materials, including microorganisms, that are applied to plant, seed, soil or other growing media that may improve the plant’s capability to assimilate useful nutrients, or deliver benefits to plant development” (Pamela et. al. 2014). Marine bioactive elements extracted from seaweed like Stimplex® and Biozest® are currently used in organic farming in order to avoid extreme application of fertilizers and improve the uptake of nutrients through the roots or leaves. A number of products that have properties to improve the plant growth are utilized as development promoters or biostimulants on vegetables, regardless of the fact that some of their active components remain unknown to the end user. Among them, seaweed products are embedded as permissible organic (natural) manures (Alessandra et. al. 2014). Stimplex® is a biostimulant derived from seaweed. It is best used in drip irrigation fertigation and applied after 2 weeks of emergence and then weekly until the end of blooming occurs. Effects of the biostimulants have been reported to increase the production by an upsurge in the efficiency of nutrient use and to provide resistance to various biotic and abiotic stresses (Zhang et. al. 2004). In a study conducted on pepper (Capsicum annuum L.) to explore the effect of natural biostimulants on yield and quality parameters of fruits, significant results, in terms of yield and other parameters like fruit quality were reported. There was an increase observed in the pigment content of leaves with the application of biostimulant and marketable yields of treated pepper cultivars as compared to their controls. The results indicated that natural biostimulants had a synergistic effect on the vitamin C and total phenolic content in pepper fruits. The antioxidant activities were also noticeably higher ($P < 0.05$) in treated plants excluding the phenolic content. (Nada et. al. 2011).Thus the use of biostimulants is considered a good approach to increase the overall production of the crop.

MATERIALS AND METHODS

Materials: Seed of eight cultivars of okra as follows: Clemson spineless, Clemson Spineless 80, Red Burgundy, Jambalaya, Red Velvet, Annie Oakley II, Perkins Mammoth and Chant. Biozest® and Stimplex® (extract of seaweed Ascophyllum nodosum) were used for treatments.

Methods: The experimental design was a complete randomized block with three replications. The trial was conducted from 7 October, 2013 through 27 November, 2013. Crops were grown using National Organic Program (NOP) standards and permitted practices. Seeds were planted in 72-cell trays containing farmer produced organic compost at the University of the Virgin Islands on St. Croix, greenhouse reared, and transplanted into the field 21 days after germination. Land preparation was done by ploughing and leveling of field with mechanical tractors. The rows were spaced 3’ apart and each plant had 2’ spacing as per the standard cultivation practices. There were 36 plants per plot for each variety for a total of 864 plants in the field. First five plants of the left row were treated with Biozest® and the remaining five were kept as a control (untreated). Similarly, the first five plants of the right row were treated with Stimplex®, while the remaining five were kept as a control (untreated). The plants were irrigated regularly after the initial 10 days. The tender pods of okra plant are harvested every two days and the data of total yield, marketable yield, and average number of fruits per plant has been calculated. No chemical insecticides, fungicides or herbicides were sprayed during this trial. Removal of weeds was done using mechanical and manual tools. After the complete period of crop production the data was compiled and analyzed using SAS 9.0 and the significant results were calculated.

RESULTS AND DISCUSSION

Significant results observed from the application of the biostimulants in okra vary according to the cultivar and biostimulant used. As shown in figure 1, Clemson spineless shows the decrease in average marketable yield and average yield per plant when treated with Biozest® and Stimplex® than the control. However, this variety has high marketable and less average per plant yield when treated with Stimplex®.

Chant is highest yielder among all of these cultivars (Fig. 1). It has higher marketable and per plant yields when treated with Stimplex® and lower yields when treated with Biozest®. Red burgundy is moderate yielder and there are not significant differences in the yields with the both Stimplex® and Biozest®, however, the treated plants of this variety yields better than the control plants.

Annie Oakley and Perkins mammoth, both varieties when treated with stimplex have high marketable and per plant yields as compare to biozest treated and control plants (Fig. 2). Clemson spineless and Red Velvet have higher average marketable yields with the Stimplex® treatment. On the other hand, in case of average yield per plant the Clemson spineless gave higher results than Red velvet when plants were treated with Biozest and vice-versa.

Clemson spineless, Clemson spineless 80 and red velvet were significantly different from each other in terms of yields with two treatments. However, in other varieties Biozest® treated plants, on average, performed poor than the Stimplex® treated plants in terms of average yield per plant. We did not find any significant differences in the average fruit weight of the okra varieties in Stimplex®, Biozest® and control plants (Table 1).

Table 1. Fruit weight (g) of eggplant varieties treated with biostimulants and control (untreated)

Varieties	Stimplex	Biozest	Control
Nubia (NA)	319.72	112.55	341.05
Fairy Tale (FT)	42.42	49.70	44.30
Dancer (DR)	217.22	214.08	216.38
Beatrice (BE)	319.32	242.80	262.40
Calliope (CE)	160.03	162.46	208.66
Orient Charm (OC)	127.58	123.27	131.91
Barbarella (BA)	211.01	229.38	281.08
Rosa Bianca (RB)	336.4	549.1	528.53
Machiaw (MW)	104.25	124.99	104.28
Shooting Stars (SS)	149.70	167.13	153.03

Figure 2: Average plant yield in okra varieties grown at the UVI Agriculture Experiment Station, St Croix.

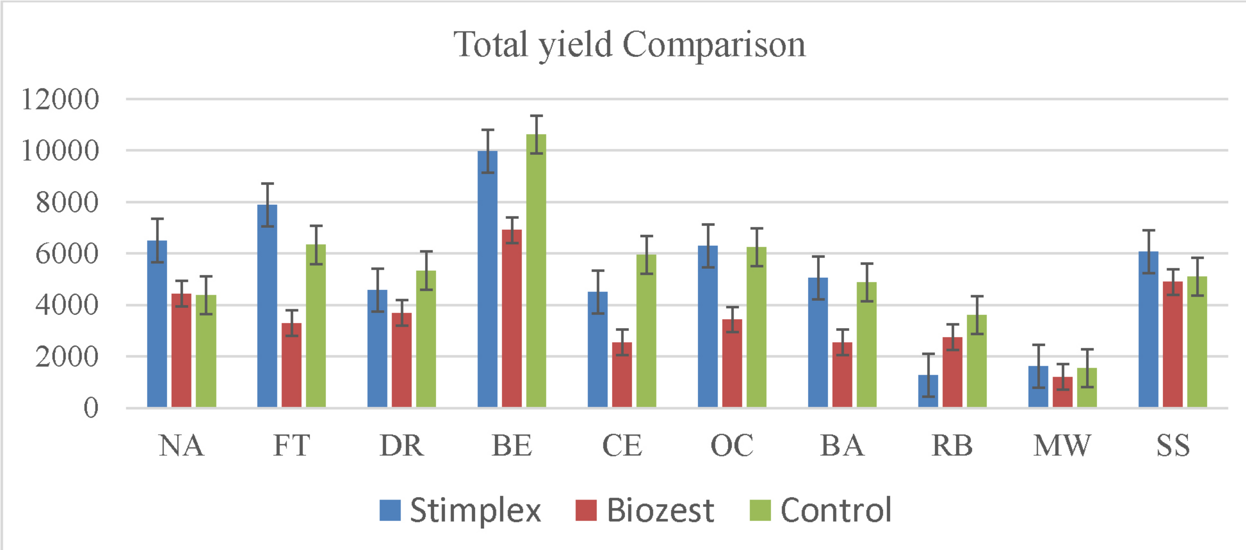
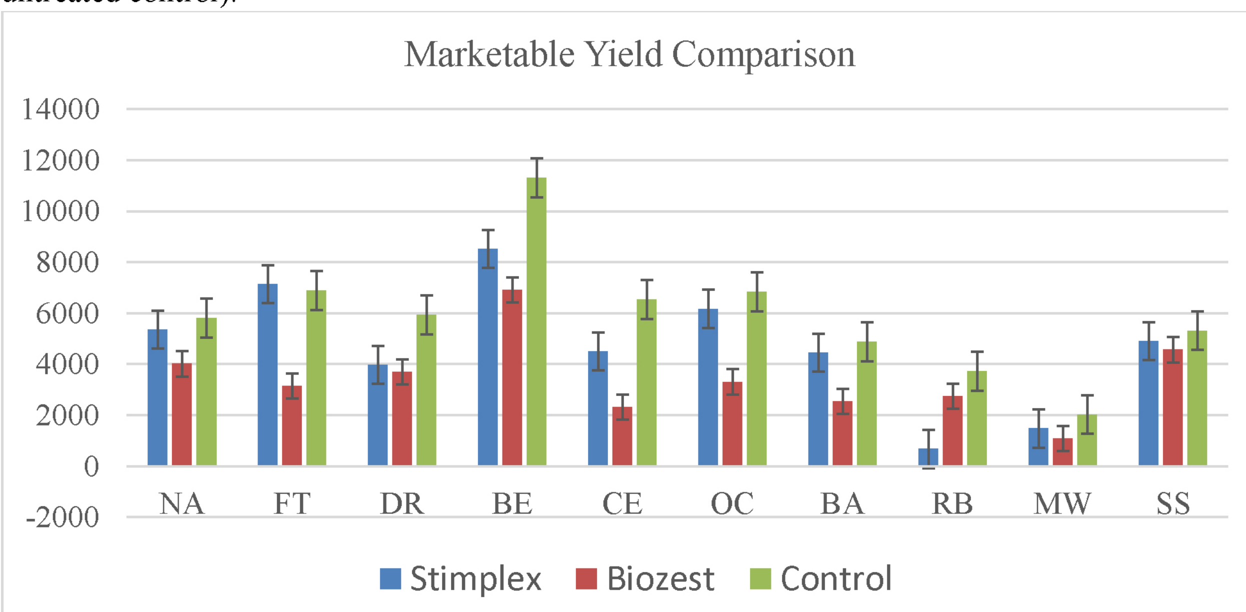


Figure 3: Okra experimental plot at UVI-AES horticultural field (plants marked with treated and untreated control).



CONCLUSION

Most of the varieties of okra performed well under the treatment of biostimulants and positive effects of Stimplex® or Biozest® for crop enhancement in organic vegetable production system were observed. Since these are the results from the one year trial, further research is needed to explain the complete benefits or effects of these biostimulants and their use in commercial production of okra.

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HYBRID RICE IN SURINAME: YES OR NO? AN OBSERVATIONAL YIELD TRIAL WITH SIX HYBRID RICE VARIETIES

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Abstract: In December 2009, SNRI/ADRON received from Bayer CropScience six of its hybrid rice varieties SRH10001, SRH10002, SRH10003, SRH10004, SRH10005 and SRH10006, which have been tested with three of ADRON varieties, ADRON-117, ADRON-125 and ADRON-130 in an Observational Yield Trial. The hybrid varieties were sown at a density of 45 kg seed/ha and the ADRON varieties at two densities 45 kg/ha and 150 kg/ha. The experiment was executed in two instalments sown some four weeks apart to see if sowing date would have an effect on the performance of the varieties. Overall, the earlier plantings gave higher yields both for the hybrids and the ADRON varieties. The later sowing date had a more profound effect on the performance of the hybrids with SRH10003 and SRH10004 yielding approximately 2 ton/ha less. The different seeding rates used with the ADRON varieties did not seem to result in big differences in yield, thus suggesting that for the inbred ADRON varieties a lower seeding rate could be applied. While the hybrid varieties gave good yields, traits as phenotypic acceptability, grain dimensions, culm strength and milling quality were not as good as the ADRON varieties.

Keywords: Suriname, hybrid rice, yield, milling quality, *Oryza sativa.*

INTRODUCTION

Rice (*Oryza sativa* L.) has been grown in Suriname for several centuries, but initially, until 1873, there was just dry land rice, grown upcountry. To this day the maroons in upper Suriname grow a large variety of upland rices in a shifting cultivation scheme under dry land conditions. The precise source of these rices remains subject to speculation. Starting in 1873, the immigrants from the Indian subcontinent and Indonesia brought Asian rice varieties and the use of commercial wetland paddies to Suriname (Van Amson, 1987). Suriname has some 60,000 ha of rice land and rice research and breeding started in the early 1940s. Surinamese rice varieties generally have stiff straw, extra long grains, smooth leaves and glumes and short to medium long maturity durations (D. HilleRisLambers, unpublished document). Suriname has a name for its extra long grain, dry cooking rice that has been developed through conventional breeding methods. Suriname's rice industry is strongly world-market oriented, and about half of the harvest goes into export. Production methods in the country are highly mechanized. They have been developed through Government support to companies and to the Foundation for Mechanized Agriculture in Suriname, SML (D. HilleRisLambers, unpublished document). In 1974, Chinese scientists successfully transferred the male sterility gene from wild rice to create the cytoplasmic genetic male-sterile (CMS) line and hybrid combination thus using hybrid vigour in first-generation seeds (or F_1) in rice. Up till then the use of hybrid technology in rice was limited due to the self-pollination character of that crop (Anon., 2004).

Hybrid rice seed production technology is different from that for inbred rice seed production, and is more complex than the seed production for many other hybrid crops (Virmani et al., 2002). Hybrid rice commands about 50% of the total rice area in China because new male sterile cytoplasm sources and inter-subspecies crosses have contributed to the development of super rice breeding in China. However, sustainable improvements of hybrid rice yield potential, grain quality, and tolerance to biotic and abiotic stresses continue to be a great challenge (Cheng et al., 2007). Hybrid rice varieties having the potential to yield 15 to 35% more than the best inbred varieties grown in similar conditions account for approximately 14% of the cultivated rice area in the world. In China alone, 90% of all the hybrid rice of the world is cultivated (Anon., 2008). Sartaj and Abeysekera (n.d.) conclude that the major challenge in indica hybrid rice breeding is to ensure that heterotic rice hybrids possess a grain quality that is at least comparable if not superior to inbred check varieties grown by farmers. Thus far, there have been no efforts at producing hybrid rice varieties in Suriname and it is unlikely that hybrid rice breeding activities will be carried out in the near future.

MATERIALS AND METHODS

An Observational Yield Trial (OYT) with six hybrid and three inbred varieties was carried out at the Anne van Dijk Rijst Onderzoekscentrum Nickerie (SNRI/ADRON) during the 2009-2010 dry season crop. Twelve treatments were used (table 1) with treatments T1-T6 for the hybrid varieties provided by Bayer CropScience at a seeding rate of 45 kg/ha, T7-T9 being ADRON's varieties also at a seeding rate of 45 kg/ha and T10-T12 comprised of ADRON's varieties at the seeding rate normally used by Surinamese farmers of 150 kg/ha.

Table 1. Treatments used in the OYT

Treatment	Variety Code	Plot area (m^2)	Seeding Rate (kg/ha)	Treatment	Variety Code	Plot area (m^2)	Seeding Rate (kg/ha)
T1	SRH10001	200	45	T7	ADRON-125	200	45
T2	SRH10002	200	45	T8	ADRON-117	200	45
T3	SRH10003	200	45	T9	ADRON-130	200	45
T4	SRH10004	200	45	T10	ADRON-125	200	150
T5	SRH10005	200	45	T11	ADRON-117	200	150
T6	SRH10006	200	45	T12	ADRON-130	200	150

The 4th edition of the Standard Evaluation System for rice (SES) was used to record the different traits (Anon., 1996). Agronomic traits as Heading (Hdg), Culm strength (Cs), Lodging incidence (Lg), phenotypic acceptability (PAcp) and Grain yield (Yld) were recorded. To assess the grain quality traits such as chalkiness (Clk), Grain length (GrL), Grain width (GrW), Brown rice length (Len), Brown rice shape (BrS) and 100-grain weight (GW) were determined. Also the Head rice yield (HRY) and the crack percentage have been recorded.

The entries were sown in plots of 40*5 m^2. Before sowing, the seeds were soaked in water for 24 hours and subsequently kept moist for 24 hours. The experiment was installed on two dates in order to see if sowing date had an influence on the performance of the varieties. The first instalment was sown on 24 December 2009 and harvested in April 2010 while the second was sown on 27 January 2010 and harvested in May 2010. The latter sowing date is considered less favourable because normally the sowing period extends from mid November to beginning of January. Urea was applied in three splits of 85, 85 and 100 kg each at 20, 35 and 50 days after sowing. Pests were treated as needed. The treatment was uniform for all plots. Water management was optimal. In short, the growing conditions were very favourable.

RESULTS AND DISCUSSION

Weather data

In table 2 monthly values for average temperature, total precipitation and total bright sunshine hours are presented.

Table 2. Weather data

Month	Average temperature (ºC)	Total precipitation (mm)	Total bright sunshine hours
December 2009	26.7	21.2	304
January 2010	26.0	78.6	299
February 2010	26.0	47.8	275
March 2010	26.4	20.2	309
April 2010	26.6	185.2	291
May 2010	26.6	210.4	296

Agronomic traits

The agronomic traits for the first instalment are presented in table 3.

Table 3. Agronomic traits for the first instalment

Treatment	Hybrid Code	Hdg	Cs	Lg	PAcp	Yld (kg/ha)
T1	SRH10001	76	9	100	7	6,884
T2	SRH10002	73	9	100	7	7,324
T3	SRH10003	78	9	100	7	7,904
T4	SRH10004	73	9	100	7	8,118
T5	SRH10005	78	9	100	7	8,174
T6	SRH10006	64	9	100	7	8,202
T7	ADRON-125	66	1	0	3	6,979
T8	ADRON-117	75	1	0	3	6,847
T9	ADRON-130	66	1	0	3	6,729
T10	ADRON-125	61	1	0	3	6,852
T11	ADRON-117	71	1	0	3	7,128
T12	ADRON-130	61	1	0	3	7,098

It shows that the hybrids had very poor culm strengths, which resulted in 100% lodging incidence (illustrated in picture 1). Perhaps the applied amount of fertilizers was too high which resulted in a vigorous vegetative growth. SRH10006 recorded the highest yield for the hybrids, while ADRON-117 did that for the inbreds. On average the highest yielding hybrid produced approximately 1100-1500 kilograms more grains per ha than the inbreds. The two seeding rates used with the inbreds did not seem to translate in a big difference in grain yield. On average the higher seeding rate resulted for ADRON-117 and ADRON-130 in a yield advantage of 300–400 kilograms per ha. By contrast, ADRON-125 recorded a higher yield for the lower seeding rate. It also seemed that the varieties seeded at a lower seeding rate flowered a few days later than the ones sown at a higher seeding rate. It could be that the higher inter-plant competition which is likely to occur more intensively at a higher seeding rate resulted in earlier flowering.

Picture 1. SRH10006 had 100% lodging while ADRON-125 stood firm

The agronomic traits for the second instalment are presented in table 4.

Table 4. Agronomic traits for the second instalment

Treat.	Variety Code	Hdg	Cs	Lg	PAcp	Yld	yield difference between 1^{st} -2^{nd} instalment (kg/ha)
T1	SRH10001	76	9	100	7	6,209	675
T2	SRH10002	74	9	100	7	6,995	328
T3	SRH10003	79	9	100	7	6,044	1,861
T4	SRH10004	76	9	100	7	6,279	1,839
T5	SRH10005	79	9	100	7	6,706	1,467
T6	SRH10006	69	9	100	7	6,730	1,473
T7	ADRON-125	69	1	0	3	5,611	1,368
T8	ADRON-117	76	1	0	3	6,574	273
T9	ADRON-130	69	1	0	3	5,930	799
T10	ADRON-125	60	1	0	3	5,648	1,203
T11	ADRON-117	70	1	0	3	7,599	- 471
T12	ADRON-130	60	1	0	3	6,180	918

The yield results for the second instalment followed a very different trend. ADRON-117 had the highest yield producing approximately 500 kilograms more grains per hectare than the highest yielding hybrid. In some instances the yield difference between the first and second instalment was dramatic, e.g. SRH10003 and SRH10004 producing in the second instalment almost two tons less per hectare than in the first instalment. This clearly is an indication that sowing date plays a very important role in the performance of the hybrids, be it more pronounced for some than others. The entries in the first instalment flowered late February-beginning March. From table 2 we can deduce that the precipitation in that period was much lower than April when the entries in the second instalment flowered. It is known that rainfall during flowering often results in lower yields. Looking at the inbreds, we noticed that ADRON-125 also appeared to have suffered from the late sowing date. It looked like only ADRON-117 benefitted from a later sowing date. The difference in heading dates for the two sowing rates appeared to have increased, for ADRON-125 and ADRON-130 even exceeding one week.

Grain quality

The grain quality traits for the first instalment are presented in table 5 while those for the second instalment are given in table 6.

Table 5. Grain quality traits for the first instalment

Treat.	Variety Code	GrL	GrW	GW	Len	BrS	100% chalk	white belly (%)	white core (%)	white back (%)	crack (%)	HRY (%)
T1	SRH10001	8.6	2.2	2.45	6.4	1	8.4	5.2	8.8	0.0	40	44.5
T2	SRH10002	9.2	2.1	2.49	7.1	1	3.2	0.4	11.6	0.0	36	44.7
T3	SRH10003	8.9	2.3	2.80	7.3	1	0.8	4.8	4.4	0.0	54	26.8
T4	SRH10004	9.3	2.1	2.66	7.2	1	8.4	11.2	8.0	0.4	5	41.3
T5	SRH10005	9.5	2.1	2.70	7.1	1	2.8	1.6	4.0	0.4	64	26.3
T6	SRH10006	9.5	2.1	2.68	7.3	1	1.6	0.4	12.8	0.0	4	55.6
T7	ADRON-125	10.5	2.3	3.10	8.1	1	0.0	0.0	1.2	0.0	6	54.0
T8	ADRON-117	10.4	2.1	2.58	8.2	1	4.4	0.0	3.2	2.0	8	52.7
T9	ADRON-130	10.2	2.3	2.89	8.0	1	0.8	2.8	4.0	0.4	4	59.3
T10	ADRON-125	10.5	2.5	3.21	8.3	1	0.8	0.1	3.6	0.0	2	54.1
T11	ADRON-117	10.8	2.1	2.56	8.0	1	2.8	0.2	5.6	0.4	8	52.3
T12	ADRON-130	10.1	2.4	2.96	7.9	1	1.6	4.4	6.8	0.1	0	57.2

Table 6. Grain quality traits for the second instalment

Treat.	Variety Code	GrL	GrW	GW	Len	BrS	100% chalk (%)	white belly (%)	white core (%)	white back (%)	crack (%)	HRY (%)
T1	SRH10001	8.6	2.3	2.69	6.4	1	10.4	14.0	6.4	0.0	17	41.6
T2	SRH10002	9.8	2.3	2.78	7.2	1	10.8	9.2	6.4	0.0	9	50.0
T3	SRH10003	9.6	2.2	3.06	7.3	1	2.6	1.2	2.8	0.0	29	33.0
T4	SRH10004	9.4	2.2	2.79	7.1	1	2.8	4.0	13.6	0.0	8	39.8
T5	SRH10005	9.4	2.2	2.77	7.2	1	0.8	9.6	9.6	0.0	41	36.7
T6	SRH10006	9.4	2.0	2.79	7.5	1	9.6	7.2	13.6	0.0	4	47.8

T7	ADRON-125	10.4	2.6	3.07	8.3	1	1.6	0.8	10.0	0.0	3	52.9
T8	ADRON-117	10.5	2.1	2.77	8.3	1	6.8	0.4	4.4	2.4	0	46.1
T9	ADRON-130	10.1	2.5	3.04	8.1	1	2.8	2.8	10.0	0.0	5	55.9
T10	ADRON-125	10.6	2.5	3.18	8.4	1	0.4	0.4	9.6	0.0	4	53.0
T11	ADRON-117	10.9	2.1	2.78	8.2	1	0.4	0.4	13.2	0.0	0	46.6
T12	ADRON-130	10.5	2.9	2.48	7.9	1	3.2	2.0	10.4	0.4	0	51.4

- grain dimensions: if the grain dimensions are considered it can be deduced that the hybrids fall in the long grain category. Suriname is known for its extra long grain rice and the mills have been adapted to processing that kind of rice. Shorter grains are also not preferred by the farmers.
- chalkiness: the hybrids seemed to have a higher incidence of chalkiness. Chalkiness is an important quality factor for the Surinamese rice since a great deal of our rice production is exported and consumers are not keen on buying rice with a high amount of chalky grains. In the rice breeding in general chalkiness is becoming a more pressing issue due to the changes in the climate of which higher temperatures affect the rice grain quality around the world. It is widely believed that higher temperatures promote the incidence of chalkiness in the rice grain.
- crack: the hybrids appeared to be more prone to the occurrence of crack in the grains which often translates in a lower HRY. This can cause a problem on most markets since these markets often require whole or unbroken grains, therefore cracked grains can reduce payments received by the grower and the miller.
- HRY: Head rice yield is a very important factor and can be defined as the weight percentage of rough rice that remains as whole rice (three-fourths kernel or greater) after complete milling. Since whole rice catches a higher price on the market, the miller will try to obtain as high a HRY as possible. The hybrids seemed to underperform with no distinction between the two installments whereas the ADRON varieties in general had a higher HRY when planted earlier in the season, but overall still scored better HRYs than the hybrids.
- Appearance: the physical appearance of the hybrids seemed a little dull as compared to the ADRON varieties. In picture 2, SRH10001 and ADRON-125 are compared illustrating the somewhat duller appearance of SRH10001.

Picture 2. SRH10001 has a duller appearance than ADRON-125

CONCLUSION

The fact that all the hybrids lodged makes them unsuitable for mechanized harvesting with a combine harvester, which is common practice in Suriname. Suriname is known for its extra long grain and all the hybrids fall in the long grain category. Farmers will not be inclined to plant those varieties and the millers will have to adjust their equipment to process the shorter grains. Head rice yield and chalkiness are important factors in the Surinamese rice sector and the hybrids seem to have a disadvantage compared to the ADRON varieties. Because more than half of our rice production is exported it will be difficult to introduce hybrids to the farmers unless these hybrids are superior in agronomical and grain quality aspects compared to the varieties, which are being bred in the inbred programme. The majority of the farmers use farmer saved seed and do not have the tradition of purchasing seed for every crop. With hybrids they will have to change their practice.

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A REVIEW OF THE PROCESSING CAPACITY OF GUYANA'S RICE INDUSTRY

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Abstract: The Guyana rice industry has experienced significant growth over the years to become one of the largest agricultural sub-sectors in Guyana. Over the last decade the industry increased yields from 3.5mt per ha to 5.2mt per ha thus increasing exports from 51,000 mt in 1990 to over 336,000tonnes in 2010. The recent success in the form of increased production due to expanded acreage and increased productivity in the increase yields; have underlined the need to assess our current processing capacity to determine whether it is sufficient to deal with the increasing production. A survey was conducted by means of questionnaires sent to all mills and data was extracted. The country has the ability to take in 13,945mt of paddy per day, however can only dry 13,281mt per day. This indicates a deficiency in drying capacity, which is more pronounced in regions 4&5 and 3.There is a deficiency in storage capacity in the country especially in regions 6 and 3 where productions far exceed storage capacity. There is an absence of the capacity to store paddy for a long term basis (more than a year), as the current system only caters for storage of 3 to 4 months. The milling capacity in the country is 256mt/hr. There is generally a lack of separate storage for finished product, since rice is mostly milled to order and is shipped within 3-4 days.

Keywords: processing capacity, drying capacity, storage.

1.0 Introduction

The Guyana rice industry has experienced significant growth over the years to become one of the largest agricultural sub-sectors in Guyana. The sale of paddy generates over G$40 billion annually which sustains roughly 20,000 farm families directly through rice cultivation and thousands more in the milling, exporting, input supply, transport sectors. The industry is export oriented where as much as 70% of the rice produced is exported with the potential to earn over US$250 M annually from exports.

Over the last decade the industry increased yields from 3.5mt per ha to 5.2mt per ha thus increasing exports from 51,000 mt in 1990 to over 336,000tonnes in 2010. These changes were due to the development of disease resistant rice varieties, increase in quality seed paddy produced and distributed to farmers, rehabilitation of the drainage and irrigation systems, and access to the Venezuela market. Yields have continued to increase with the recent release of new varieties where yields were averaging 5.4 mt/ha for the first crop for 2013.

The recent success in the form of increased production due to expanded acreage and increased productivity in the increase yields; have underlined the need to assess our current processing capacity to determine whether it is sufficient to deal with the increasing production. This need was emphasized during the first crop of 2013 where the delay in marketing arrangements with Venezuela led to the non-movement of paddy and rice for most of the harvesting period. During this period the industry's ability to store and dry the harvested paddy in a timely manner were put to the test. Had the marketing arrangement not been completed in May, the situation may have arisen where the entire crop may have had to be harvested and stored. Had such a situation occurred, the question that begs an answer is whether it would have been possible. This study is aimed at answering this question by seeking to update the processing capacity of Guyana rice industry.

2.0 Methodology

Data was collected for this study by way of questionnaire and interviews. A questionnaire was designed to collect information on the various aspects of rice processing from the intake of paddy, drying, storage and milling. The questionnaire was discussed with the Quality Control Manager and Regional Supervisors at their Monthly meeting before being distributed. The questionnaire was distributed by the Regional supervisors to the mills in the various regions. Two weeks were scheduled for the distribution and collection of the questionnaire from the mills after which analysis was done.

3.0 Findings

Rice Cultivation in Guyana is spread in five of the ten administrative Regions: 2, 3, 4, 5 and 6, the summary of findings for each region is presented. Rice grown in Region 9 is part of a special project and was not considered in this study.

3.1 Intake

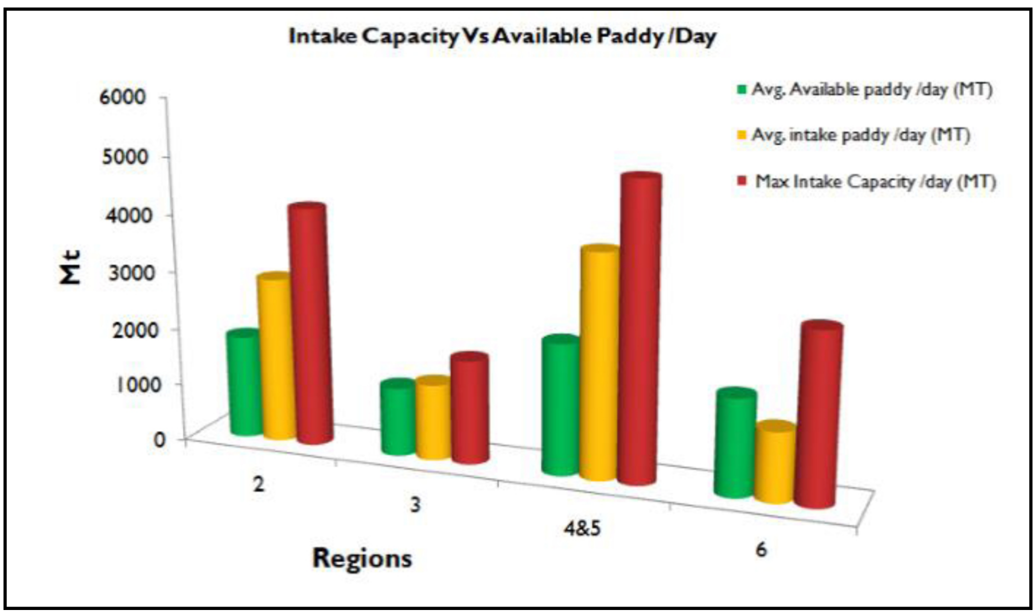
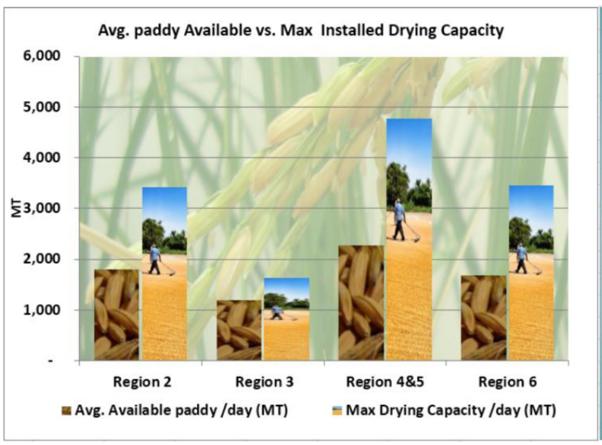


Fig. 3.1 Intake Capacity vs Estimated Average paddy available for Purchasing per day

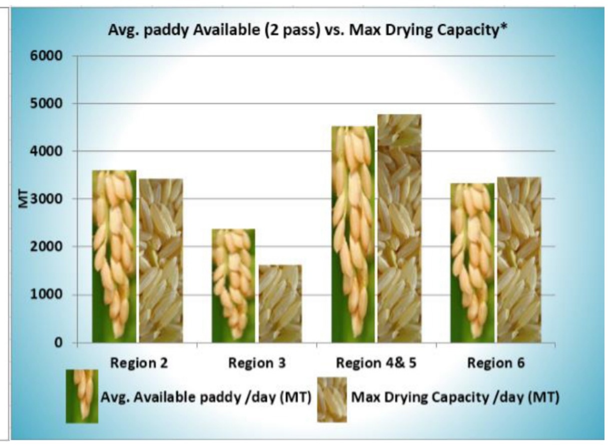
Intake capacity refers to the amount of paddy a mill can purchase and take into its system per day, the activities during intake involves sampling, grading, weighing and discharging. Paddy starts to deteriorate immediately after harvest. This process is suspended by a reduction of the moisture content of the grains (drying) allowing for paddy to be stored safely for long periods. Thus, delays or inefficiency at any point in this system will affect the rate of harvesting and would lead to losses infield, and post-harvest losses in quality. It was found that the average intake capacity of mills in all regions with the exception of region 6 was adequate to process the estimated average paddy available for purchasing (Fig.3.1). The estimated average paddy available for purchasing per day is calculated by determining the average hectares harvested per day times in each region and multiply it by the average yield for the region. It must be noted that this situation exist when all mills are actively purchasing paddy, if one or more mill do not purchase for the crop, the situation changes. Maximum intake refers to the total amount of paddy the mill can take in; this refers to taking in paddy but not necessarily going into the drying system immediately, usually paddy is store in heaps on the drying floor until space is available in the dryer.

3.2 Drying

Drying capacity refers to the mills ability to reduce the moisture content of the paddy it takes in (purchase) to 14% of below for safe storage. The reduction of moisture through drying stops the biological and chemical process within the grain that leads to deteriorating, thus drying and dry capacity are crucial elements in a milling system.



(a)



(b)

Fig. 3.2 Drying capacity vs. (a) One and (b) Two Passes in the dryer with Paddy Available per Day

Paddy is harvested at moisture content ranging between 18- 28% and has to be brought down to 14% for safe storage. Most mills achieve this by two passes; or a two stage reduction with tempering period between. It was found that the country has an installed drying capacity of 13,280 mt while the average paddy available for purchasing during per day was 6,931 mt. This would imply that there is an over capacity of 6,349 mt (Fig3.2a) however, when the practice of drying the paddy in two passes is considered; (the same amount of paddy has to be dried two times) a deficiency in drying capacity of 582 mt is exposed (Fig3.2b). Comparing the Regions, it is seen that deficiencies exist in Regions 2 and 3 while the margins in Regions 5 and 6 are slim. It was found that that in several instances, deficiencies in drying manifested not because of lack of dry capacity but due to factors such as lack of tempering bins and storage resulting in the dryer becoming a temporary storage facility.

3.3 Storage

Safe storage time is the period of exposure of a product at a particular moisture content to a particular relative humidity and temperature below which crop deterioration may occur and beyond which the crop may be impaired. The findings revealed that the industry possess the capacity to store 378,976 mt of paddy per crop, however the average production for the last three crops is 385,330mt, representing a deficiency in storage capacity of 6,353mt. This suggest that if needed the industry is not capable of harvesting and storing an entire crop production. Comparing the Regions, the greatest deficiency exists in Regions 5 and 6 while region two is the only Region in which capacity exceeds production (Fig. 3.3-1).

It was found that most mills store paddy for three to four months; thus all paddy is milled and sold before the commencement of the second crop. The deficiency in storage capacity has been countered by milling and exporting as paddy is being purchased from the farmers. For this system to be effective, markets have to be in place at the commencement of the crop so that as paddy is coming in, rice is being sold. It has been observed however, increased production in recent crops results in more and more carry over stock(all paddy is not sold before the commencement of the next crop), this situation further reduce the storage capacity the mills. Another factor that reduces the storage capacity is that some mills do not operate for a crop or do not operate at full capacity for various reasons.

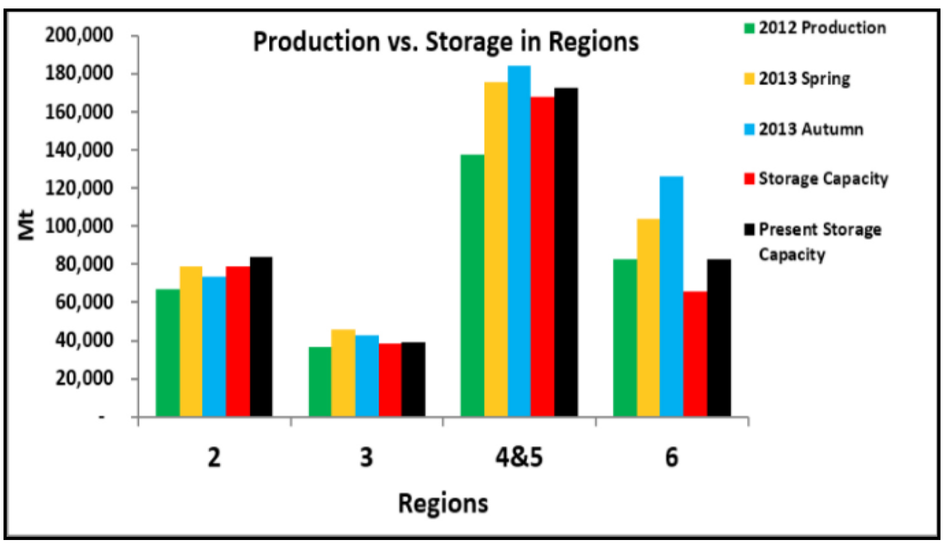


Fig.3.3-1 Storage Capacity vs. Production in Regions

4.0 Discussion

The processing capacity of the industry as the results of this study points out, could be viewed as not being in sync with production. This is evident in key areas such as drying and storage; the industry has a total storage capacity per crop of 350,278mt, a difference of 54,688mt between storage and production for the 2013 spring crop. By August 2014 storage capacity would have increased to 378,976 mt however paddy production for the 2014 spring crop was at 481,693 mt; a difference of 102,717mt. this suggest that while efforts to increase capacity is being made in the processing sector the continuous increase in production results in the status quo remains the same.

The findings of this study indicates that the industry currently lacks the capacity to store paddy on a long term basis (more than a year) without affecting normal operation. The industry currently operates on the basis that paddy harvested for one crop is milled and sold before harvesting for the next crop begins; this method ensures there is space to accommodate the next crop. However, if there is some amount of carry over stock, the capacity of the mills for the next crop will be reduced. Because of this method of operation the length of time paddy is stored for is 3 to 4 months, since paddy must be sold to bring in the cash flow to pay farmers. This system does not provide any incentive for millers to keep paddy long, since they need the space to continue operation, and the cash flow to pay farmers. The disadvantage of this system is that the prices received by millers for their rice and by extension the farmers for their paddy is subjected to fluctuations in the world market.

The drying capacity of a mill usually affects the intake capacity of the mill, this is because paddy coming in from the field must be dried before storage to maintain quality. The fact that the intake capacity is greater than that of the drying would indicate that some amount of paddy may have to be stored before it can be dried. When this occurs, quality deteriorates more rapidly and may result in discoloration. There appears to be a need for increased drying capacity so that to facilitate faster intake resulting in an increasing harvesting rate. One area of concern is the lack of separation of different qualities of paddy purchased. Most mills indicate that all paddy is stored together regardless of quality. This practice limit the ability of the mills to manage their stock and the ability to meet quality various quality requirements; may not be able to access good quality when needed , or blend good quality with poor to meet contract requirements. The industry has a milling capacity of 256mt/hr, finished product (milled rice) is generally stored within the mill area, with only a few mills having separate storage. It was also observed that interest in setting up separate storage for milled rice is limited since in most cases rice are milled close to shipment.

5.0 Conclusions

The Rice Industry of Guyana has had recent success in the form of increased production due to expanded acreage and increased productivity in the increase yields; this have underlined the need to assess our current processing capacity to determine whether it is sufficient to deal with the increasing production. Conclusions drawn from this assessment are as follows;

The country has the ability to take in 13,945mt of paddy per day, however can only dry 13,281mt per day. This indicates a deficiency in drying capacity, which is more pronounced in regions 4&5 and 3. There is a deficiency in storage capacity in the country especially in regions 6 and 3 where productions far exceed storage capacity. There is an absence of the capacity to store paddy for a long term basis (more than a year), as the current system only caters for storage of 3 to 4 months. The milling capacity in the country is 256mt/hr. There is generally a lack of separate storage for finished product, since rice is mostly milled to order and is shipped within 3-4 days.

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PROSPECTS OF AGRI-TOURISM IN LUDHIANA DISTRICT OF PUNJAB STATE

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Abstract: Agri-tourism is considered as a tourist activity, which combines agricultural or rural settings with products of agricultural operations all within a tourism experience, provided by rural people to attract tourists in order to generate extra income for their businesses. Punjab has a rich spectrum of landscape, forest, wildlife and cultural diversity which has the potential to become an eco-agri-tourist destination. However, although agriculture is the main occupation, it is becoming unprofitable due the irregular monsoon, prices fluctuations of agro-products etc. Since no study has been conducted in this context in Punjab State, there is need for innovative activities which will enhance the rural people. As such the present study entitled “Prospects of agri-tourism in Ludhiana District of Punjab State” was undertaken with the objectives to study the opinion regarding agri-tourism, to study the prospects of agri-tourism and to suggest strategies for the promotion of agri-tourism in Punjab state. 110 teachers/principals were selected from 10 Government/Private schools. 60 under graduate students were selected from two Colleges and forty urban consumers were selected from the locality of Ludhiana. Distributed questionnaire approach and personal interview method were used to collect data. Findings revealed that majority of respondents of all categories belonged to urban family background. Most teachers had educational qualification of post graduation and service experience of 1-12 years. Most teachers and students have medium social participation, while most urban consumers had low social participation. Although more than half of the total respondents were not aware of agri-tourism, 3/4 of them were willing to visit an agri-tourism farm. More than (80%) of the total respondents were willing to participate in agricultural activities on an agri-tourism farm, 3/4 were willing to interact with the rural people. Educational qualification and service experience had significant and positive correlation with opinion to agri-tourism.

Keywords: Agri-tourism, opinion, prospects, strategies.

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USING LOCALLY PRODUCED MILK TO PRODUCE FRESH YOGHURT AND COTTAGE CHEESE: THE POTENTIAL FOR THE LOCAL DAIRY INDUSTRY

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Abstract: Over 3 million liters of fresh cow's milk and 1 million liters of fresh goat's milk are produced in Trinidad and Tobago annually. Eighty percent of the cow's milk is sold to the Swiss food and beverage giant Nestle at a subsidized price of 2.15 TTD/L. The state through the Ministry of Food Production contributes a further 1.50 TTD for every liter produced by registered dairy farmers. Goat's milk is sold as pasteurized milk at 40 TTD/L from individual small-medium farmers. Acidified dairy products use milk processing techniques to convert fresh milk into healthy products with extended shelf life. Currently, several foreign brands of cottage cheese and yoghurt are found on supermarket shelves, with an average retail price of 80 TTD per 600g and 7 TTD/30 mL respectively. 5 L of fresh milk yields approximately 2.2 kg of cottage cheese or 3 L of yoghurt. Both products can be easily made and are in high demand because of their neutraceutical properties by dieters, immuno-compromised and lactose intolerant persons. The objective of this study is to evaluate the economic feasibility of utilizing fresh milk from dairy farmers to produce fresh yoghurt and cottage cheese for the domestic market. Trinidad and Tobago's dairy industry has the potential for creating employment and ensuring food security by processing fresh milk into acidified dairy products to meet the local demand for these products.

Keywords: Dairy Industry, Acidified Dairy Products, Cottage Cheese, Yoghurt, Food Security.

Introduction

Food and Drug Regulations of T & T (1969). Milk is the normal lacteal secretion obtained from the mammary gland of the cow, genus Bos, and shall be free from colostrum, and shall contain: (a) not less than 3.0 percent of milk fat; (b) not less than 8.5 percent of milk solids not fat; (c) not more than 20 parts over million dirt (by dirt means all matter insoluble in, and foreign to milk as it leaves the cow's udder). The milk of animals other than bovine species shall be give a designations appropriate to its source"

Milk is considered a whole food as it contains Water, Proteins, Carbohydrates, Minerals, Vitamins and Fats. However it may also contains Biological and Chemical contaminants. This makes it susceptible to spoilage and causes loss of income for dairy farmers. Within the dairy industry in Trinidad, there has been a rising interest in the area of value-added dairy processing however as the law only recognises milk as coming from cows the price is not regulated for milk from other animals this has its advantages and disadvantages. This report engages to show the opportunities and challenges of value-added processing. Our dairy industry is a regulated industry in the Food and Production Ministry (Livestock Division) as it requires a marketplace with considerable government oversight to guarantee orderly marketing, balancing the supply and demand, and to assure the quality and consistency of the product. This type of value added project will only succeed with a thorough understanding of the consumer, marketing channels, adequate equity investment, legal foundation and a firm commitment by a team of individuals who are willing to work towards a common goal.

How we are losing this fight.

Domestic milk production was once linked to government food procurement programmes e.g. the National School Feeding Programmes (NSFP). 30,000 packets (250ml) of flavoured imported diary products are offered to the students per week however it is outsourced by Universal Food Ltd as subsidiary of Associated Brands Limited as Nestle was no longer awarded the contract. Pine Hill and the MOO line is found on our shelves, however a container of Nestle products was denied entry in to Barbados as it did not meet the country standards, this came about when a consultant was dispatched to TT, found, that some cows were being milked manually and this resulted in Nestle being shut out of Barbados market, a counter action due to issues of being shut out of our market due to its "non- compliant" labelling. Our market needs to be protected even in the face of free trade. In March 2013 The Ministry of Food Production purchased 60 heads of cattle (55 heifers - and 5 bulls) from United States to improve the genetics of the local dairy population. The beef cattle bull was Angus red, while the others were Holstein and Jersey. This was necessary because as of 2013 there were only 2500 dairy producing cattle in Trinidad and Tobago and local milk production fell from 52% of consumption to 27% between 2000 and 2010. Nestle entered into an agreement with the MOFP and established a partnership for long term development of a sustainable and profitable diary industry by 2015. This is in relation with the National Food Production Action Plan 2012-2015 to import 100 pregnant heifers per year. Since then we have imported more of animals and are due to be released from quarantine as of 27th May 2015 to farmers who have met all the requirements. While it was more feasible to import the Jamaican Hope as it is a known, large volume milk producer, issues with the Blue Tongue disease, prevented its importation. It must be noted that we have confirmed cases that have not been reported so unrevised policies prevented the importation of the best suitable animals for our climate.

The shortfall – there is little development in our unexploited "Invention" the buffalypso who's milk is perfect for mozzarella cheese, as cheese made from this milk is much in demand all over the world and as this milk contains twice as much butterfat as cow's milk. "Rather than exploit this valuable asset, we have allowed the number to decrease and some herds no longer exist. The importation of cattle from North America has resulted in the introduction into the buffalpyso a new disease-Brucellosis." Quoted by The late John Spence-professor emeritus-UWI. On April 1st 2012. The idea was taken by an Italian photographer who was on assignment to the village of Grande Riviere, he abandoned his former way of life and settled to pursue his dream of cheese making after he noticed the amount of water buffalos whose milk was not being used. His business Dolce Valle was registered as line of dairy products in which the label reads-(milk, salt and love and care) and now I guess with added herbs and spices.

From Dairy to Dairy Aisle

Raw Milk

Even now as some of our population are involved in organic and commercial agriculture, food security is virtually still out of our reach but we can change it with Value Added Dairy Processing. Dairy processing starts with raw milk, on average milk contains 87% water and 13% solids. The solids make up of fat solids and non fat solids that carry vitamins A, D, E, and K. The non fat solids include protein and must be transported to the processing center at 4°C. Dairy Processing Centers should have significant raw milk storage as it a best that the milk collected be utilized in one day.

What is Cottage Cheese?

Cottage cheese is a source of protein and calcium, but offers multiple applications, ranging from sweet deserts to savoury snacks. It is a fresh, uncured, moist cheese that is highly perishable. Pasteurization, packaging innovations, use of carbon dioxide and the use of additional antimicrobial agents have minimised the need for artificial preservative. However, some brands of commercial cottage cheese do contain the artificial preservative E3202 Potassium Sorbate, - GRAS in combination with the natural antimicrobial Natamycin[1]. To inhibit mould, yeast, and spoilage bacteria. The Brand that are available in our market local Dolce Valle Dairy and Yumma. International brands Daisy, Odyssey Bel Gioloso, Sargento and Axelrod.

The benefits of eating cottage cheese are:

Weight Management: Low fat and no fat cottage cheese have the reputation as a diet food or a weight management food. Low or no fat cottage cheese packs a lot of punch without a lot of fat, carbohydrates and sugar. As previously mentioned, cottage cheese contains a large amount of casein. Casein makes you feel full and unlikely to snack on other less healthy foods. Cottage cheese is popular with dieters because it fills you up, is low in calories and high in protein.

Muscle Development and Maintenance: Cottage cheese is popular with athletes and fitness buffs as well, due to the amount of protein and calcium gained without fat. The protein and calcium in cottage cheese play a major role in the development, repair and maintenance of the muscles.

Bone Development and Maintenance: The combination of calcium and phosphorus results in greater bone density and cottage cheese is the perfect source of these two minerals.

Teeth and Gum Health: Calcium is vital for the health of the teeth and gums. Cottage cheese is full of calcium to assist in bone development and prevent osteoporosis.

Nerve Functions and Blood Clotting: The healthy functioning of the nervous system, circulatory system and neurological functions depend on a healthy presence of calcium, which cottage cheese has in abundance.

International producers are DSM, Dairy Land Canada, Tnuva, Terrace Park Dairy, Westby Creamery and Manta –Crowley Foods LLC, The Cottage at Bell Haven, Garelick Farms LLC.

Yoghurt/ Greek Style Yoghurt- This product results from culturing a mixture of milk and cream product with lactic acid producing bacteria. Lactobacillus *bulgaricus* and Streptococous *thermophilus*. Yoghurt contains not less than 3.25% milk fat and 8.25 milk fat and 8.25 % non fat solids. Low fat yoghurt contains not less than % milk fat. Non Fat Yoghurt less than 5% milk fat. Basic yoghurt can be made with half a gallon Milk, Starter (cheddar cheese, or 3tbs of plain yoghurt. Rendering milk into Yoghurt effectively doubles the price. Production cost plus profit – minus overheads like packaging, facility cost, energy cost, labour cost and shipping-equal a commercial product when the primary concern is the corporate bottom line. The distribution and cost will involve further energy cost and vehicle management.

To increase their profit margins and offset the cost to produce milk Dairy processors must work to establish a niche in this market and it can be obtained by promoting the product in the following ways.

Better Flavor: More solids create a smoother taste however consumers are looking for reduced fat in their products.

Increase Shelf Life: Can be difficult with distribution cost rise as it may be difficult to deliver to various routes on a daily basis. The use of CO^2 has been known to increase shelf life.

Perceived Quality: Control the quality and create an image of high quality. Consumers are likely to pay a premium price for perceived quality. The foreign brands are full of chemically produced hormones, pesticides, herbicides, artificial colors, artificial flavors, flavor enhancers, and preservatives. Locally produced product don't require.

Organic: Require substantial premium and is susceptible to dramatic changes in consumer preferences. Organic farming starts with GAP and GMP.

Packaging: Decorative containers.

Direct Delivery (Home Delivery): there is a sector that will pay a premium for direct delivery to home or offices. The cost of distribution is high so consumer must be willing to pay. Delivery to home and offices are ideal for this type of business.

According to CSO results milk has been in the decline since 1999 from 20,482.6 (000 Liters) to 8632.4 (000 Liters) in 2010.

Trinidad Diary sectors and its production:

Approximately 150 farmers in five milking Districts in Trinidad (Turure, Waller Field, Charlieville, Carlsen Field and Woodland -Penal. Nestle purchases 3 million kg of milk on an annual basis from these farmers. The price - TT $2.15 kg with a quality bonus of TT$0.23/kg of TCP Total Plate Count of <250,000 cfu (colony forming units)/ml and addition TT$0.12 for TS Total Solids of >11.5%. Government pays a direct subsidy to the farmers of TT$1.50 only if the milk is sold to Nestle. Under world trade rules, subsidies can be lowered but not raised and that is bad news for farmers as the government hands on subsidies are tied. Medford farms in Carlsen Field is the sole supplier to The Ramsaran Product Line at TT$8.00 p/l and also supplies restaurant in Port of Spain at TT$10.00 per litre. He encourages the farmers to bring in their milk to his farm and in turns acts as a distributor on their behalf to Nestle. The Owner Chris Medford is a 2nd generation farmer and a MBA graduate. Not waiting on the government he takes the reigns an injected life in his farm by importing genetically altered frozen seamen from Canada and the US, the result one of his cow can produce four (4) to six (6) gallons of milk while on average in T&T a cow produces 1.5 gallons a day. Milk not sold, is sold at the farm gate either as raw milk or value added products like yoghurt or Ghee. Farmers claim that Nestlé's policy reduced collection station from 14-2 as they required the milk to be 4 degrees within three hours of leaving the cow. This policy the farmers claimed forced a number of farmers out of business.

To assist the farmers that stayed in business the TT Dairy Association assumed management of the collection station at Turure and upgraded the collection station in Charlieville and Woodland in Penal.

Marlissa Farms in Penal has 400 goats that are milked producing 350 kg - 400 litres of goat's milk daily (146,000 annually). However the amount of milk can be varied if they decided to adjust the animal diet as it was required in the past as production ran high and the milk had to be dumped due to lack of space. Their milking machine can milk 40 goats at a time and is sensor activated to avoid over milking the animal that can result in damage of the teats.

Results and Discussion

The Farmers Association of Trinidad and Tobago called on the Government to fix important issues in dairy farming before attempting to importation of cows, such as improving infrastructure on farms and giving land tenure, training and increasing the amount paid to farmers for their milk production. The government are not subsidizing farmers they are subsidizing Nestle and as they were forced to pay one third of the cost of the imported cow while the price of milk remain $3.88 in 2013 to $4.00/kg in 2015. However as quoted by Nestle this will be increased to TT 4.20/kg from June 1st 2015. The cost for farmers to produce milk has risen by four and six dollars in 2006 by eight dollars as of 2013 while the price paid by Nestle remained stagnant

Marlissa Farms produces 400 liters a day from 400 milking goats and sell 1.8 liter bottle at an average price of $59.00 while imported goat milk is sold at supermarkets costing $37.49.per lt. The farm is also supplying milk to a cheese-maker in St. Ann. The 30,000 packets (250ml) of flavored dairy products are offered in NSDSL costTT2.85 ea with a monthly consumption of 30,000 liters at a cost of $265,500 TTD (40,079 USD) per annum. This is a potential large niche market once precautions are taken as it's a high risk foods served to children. Homemade yoghurt is healthier as it lacks the artificial thickening agents and sweeteners as in the commercial types Temp over 130 F will kill the yoghurt bacteria. Further information of imported commodity for Trinidad and Tobago can be found in the online US Comtrade Database.

Conclusion

Milk according to the world Atlas Milk Production is at the lowest since 1972 which was at 17,703.33 Hg/An to 2,991.43 Hg/An. The shortfall of local production has traditionally been met through imports of milk powder and up to recently liquid product including fresh UHT and other milk drinks. **These imports are growing at a rapid rate aided by government policies to enhance access to 'cheaper foods'.** The Government has established that the local dairy industry is essential to food and national security, employment and rural incomes. However despite all efforts fresh mil production is in crisis with dwindling profits, shrinking markets, no incentives and a lack of clear rules for the management of milk powder imports.

Also children of the farmers were not interested in farming and the parents who own the farms do not want their children to become farmers and this resulted in the farms becoming abandoned. There were also reports of cattle roaming the street causing danger to residents The Livestock Product Board requested that all animals be stamped with a number and the name of farm so the owners could be held responsible, however that was discontinued as that department no longer exist. While worldwide dairy consumption continues to grow every year, agriculture is faced with significant challenges on the global level; which is to produce more with less impact on the environment.

We are challenged in "The 2050 Criteria" , from the World Wildlife Fund -"Over the next 40 years, land, energy, water, and weather constraints will place unprecedented pressure on mankind's ability to access its most basic goods – food, fuel, and fiber. Humanity must now produce more food in the next four decades than we have in the last 8,000 years of agriculture combined. And we must do so sustainably."

The existing world systems currently support 7 billion humans, or more correctly, adequately support about 6 billion with another 800 million or so suffering from food insecurity, malnutrition or hunger. The FAO projects that the world population will grow to more than 9+ billion by 2050, requiring a 70% increase in food production.

While there has been considerable progress made in the science and practice of agriculture in the world, we have to produce more food and fiber on about the same acreage as a century ago with less labor, energy and water per unit of output and with considerably less soil erosion. The projected population growth however will intensify the challenges in terms of declining quality of water, soil and air, loss of genetic diversity, rising input costs, loss of farmlands.

We need to increase in the imported tariff so that dairy farmers would be encouraged to produce more milk" Farouk Mohammed director of the Livestock and Livestock Product Board (December 13th 2011)

Sustainability efforts can not fall on any one group of stakeholders. A joint responsibility of many parties including but not limited to: consumers, health professionals, retailers, food industry (including producers and manufacturers) and mostly the government. A key solution is to follow PHD Pine Hill Diary and move to an ultra-pasteurised processed, along the use of Tetra Gemina Aseptic packaging away from the Swiss company Nestle control.

Issues these stakeholders must address are:

Greenhouse gas emissions (carbon footprint); Water Supply and Usage; Reduction in Biodiversity; Ability of our food supply to sustain us and promote health; Impact of farming on the local economy; Good animal welfare

Sustainability in the Dairy Industry.

Our aim should be to produce healthy, nutritious and affordable dairy products in our country with the focus on the relationship between animal welfare, sustainable farming and the milk quality for human consumption. We should set by example, environmental stewardship and innovation by always looking for ways to improve upon our practices and processes in Water Conservation; Waste Management; Air Quality; Farm Management Practices and Diary Farm Expansion.

Diary Farming in Trinidad and Tobago can be protected through:

Environment Control- Developing a livestock policy: Livestock Database : Developing a forage farm; Developing training manuals.; Promotional campaigns such as fairs and exhibitions; Value added product development and training and assistance in grading and branding and extension services to assist dairy farmer.

Milking Equipment Management, Dry Cow Therapy Training, and Proper Milking Technique.

Improved feeding programs in Trinidad and Tobago

Mulato and Mulato II are improved grasses introduced to TT. A combined effort of CARDI Nestle, UWI and the Sugarcane Feeds Centre, A product of 20 years research of the International Center for Tropical Agriculture in Columbia. It is highly recommended by CARDI to mitigate against the rising price of grain and also the issue that feeding the animal GMO corn was producing an acid resistant strain of E-Coli. Mulato and Mulato II is related to the Tanner grass, which was locally fed to the animals. This product is an improvement in terms of dry matter yield, leaf to stem ratio, nutrient content, pest resistance and persistence. Its rooting system can withstand grazing and trampling with quick regrowth. Adaptable to acid infertile soils and drought conditions this will make it ideal for the unused sugar cane lands. Diary farmers have reported milk yield on this grass in some cases a 23% increase.

This report is not meant to be an all-inclusive template or a business start up venture but a general overview of the marketplace for dairy products and the production and process mechanics for value added venture. Additional Marketing research should be done with the assistance of competent experts in the field. There is an additional levels of risk for value added dairy ventures, as by their nature, are perishable and require solid and consistent quality controls procedures which require investments in time, money research and effort from the business owners.

While from the import figures listed above the market exist for Value added dairy products as shown using the last year for reference.

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COMPARISON OF ETHANOL PRODUCTION FROM TREATED AND UNTREATED CANE MOLASSES USING *SACCHAROMYCES CEREVISIAE* AND *ZYMOMONAS MOBILIS*

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Abstract: In recent years, the use of agricultural products to produce alcohol for fuel has gained worldwide interest. Several economic studies, on the feasibility of growing crops to provide sugar for fermentation into alcohol were resulted in pessimistic to optimistic conclusions. By encouraging the use of bioethanol, the rural economy would also receive a boost from growing the necessary crops. The depletion of fossil fuel reserves, the unstable panorama of the petrol prices and more recently, increasing environmental and political pressures has increased industrial focus towards alternative fuel sources, and encouraged the search of products originated from biomass, as renewable sources of energy. Fermentations utilizing strains of Zymomonas mobilis, in place of the traditional yeasts, have been proposed due to their ethanol yields being close to theoretical. In molasses, dark colours are present that can be removed by adsorption process using activated charcoal. Ethanol production from raw cane molasses will be compared with treated molasses using S. cerevisiae and Z. mobilis in stationary flask fermentation. Ethanol production from sugar cane molasses will be analyzed under different culture conditions using Z. mobilis in batch fermentation.

Keywords: sugar, bioethanol, renewable sources, energy.

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EFFICACY OF ANTIOXIDANTS TO REDUCE THE TOXICITY OF AFLATOXIN B1 (AF) IN WEANLING PIGS FED DIETARY TREATMENTS FOR FOUR WEEKS

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Abstract: The objective of this study was to determine the efficacy of two antioxidants to prevent or reduce the toxic effects of AF in weanling pigs fed dietary treatments for four weeks. Thirty weanling pigs (2 weeks post weaning) were purchased, weighed, ear tagged, and allotted by weight to dietary treatments. Each pig was individually housed with ad libitum access to feed and water. A completely randomized design was used with six 5-week-old barrows assigned to each of 5 dietary treatments. Dietary treatments included: 1) basal industry type weanling diet (BD) containing no adsorbent or mycotoxins); 2) BD plus 1 mg/kg AF; 3) BD plus 200 mg/kg theracurcumin (TCM); 4) BD plus 200 mg/kg curcumin (CMN); 5) BD plus 1 mg/kg AF and 200 mg/kg TCM; and 6) BD plus 1 mg/kg AF and 200 mg/kg CMN. Compared to controls, weight gain (WG) was not significantly different with the addition of TCM and CMN (15.41 and 16.49 vs. 16.31 kg) to the BD. When AF was included in the diet there was a significant decrease in WG compared to the controls (10.68 vs. 16.31 kg), and the addition of TCM and CMN did not significantly change WG (9.6 and 9.5 vs 10.86 kg). Relative liver weight was not significantly different among the control, TCM, and CMN diets (2.51 and 2.47 vs. 2.47%). Liver weight significantly increased with the addition of AF to the diet (2.95 vs 2.47%), and when TCM and CMN were added to the AF diet there was no change in comparison to the AF diet (3.10 and 3.15 vs 2.95%). There were no negative effects from the addition of TCM and CMN to the basal diet, but there were no improvements in regard to reducing the negative effects of AF.

Keywords: antioxidants, efficacy, aflatoxin (AF)

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RESIDUAL LEVELS OF FURAN IN SOME CARIBBEAN FOOD AND ITS KINETIC INTERACTIONS WITH LOW MOLECULAR WEIGHT BIOLOGICAL REDUCTANTS

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Abstract: The potential carcinogenic effects of furan on humans and the recent discovery of furan in commercial foods have stimulated tremendous interests; prompting the investigation of the levels generally found in food across the world. The concern of the scientific community is whether furan may cause cancer in humans through long-term exposure to very low levels. Determining the levels of furan found in food and identifying precursors naturally present in food justifies research in obtaining valuable information to alleviate this concern. Caribbean foods that are both commercial and home-prepared were selected for determination of residual levels of furan. The method applying Purge and Trap Gas Chromatography Mass Spectrometry (P&T/GC/MS) was validated and used to quantify residual levels of furan in some Caribbean fruit juices. Furan was quantified in commercial juice samples with a limit of detection (LOD) of 0.2 ppb, limit of quantification (LOQ) of 0.7 ppb and recovery of 97-103% with a RSD $\leq$ 10%. The levels of furan found in the commercial juice samples were below the LOQ. The method of Headspace Gas Chromatography Mass Spectrometry (HS/GC/MS) is currently being employed to detect and quantify the levels of furan in a wide range of Caribbean foods, such as coffee, milk products, soups, meats, fruits, pastries and snacks. The volatility of furan makes the study of its kinetic interactions very challenging and as a result different methods are being explored. To date, the kinetics of the interactions of furan with low molecular weight biological reductants such as glutathione, and the interactions of glutathione with model furan metabolites, such as butyraldehyde, were investigated spectrophotometrically.

Keywords: Furan, Carcinogenic, Caribbean foods.

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INVASIVE PESTS: A CHALLENGE IN PLANT SECURITY

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Abstract: The introduction of non-native species into new geographical regions often perturbs natural habitats. Some exotic species are ranked as invasive because they cause economic or environmental problems. Particularly relevant are non-native species introduced into agroecosystems where they grow into destructive pests and become a challenge for food security. While prevention of entry obviously is the first line of defense and most cost-effective mean against new introductions, examples of bioinvasions threatening main crops in many countries are unfortunately frequent. By taken examples from the Acari, I present here how understanding invasion processes can help not only to prevent entry but also pest spread. With a focus on the red tomato spider mite, *Tetranychus evansi*, I illustrate how population genetics and modelling approaches gave evidence of the complex multiple invasion events and timing of introductions occurred for this cryptic species. Being native to South America it has emerged as a new destructive pest of solanaceous crops in several other continents. As in many other cases of invasion, prevention failed and means to mitigate new pests are explored. Biological control, as a component of integrated pest management strategy, provides good opportunities for implementing environmentally acceptable control of pests. Interestingly, as it is the case in invasions, in biological control programs beneficial organisms are introduced into crop systems. Studies here presented illustrate how gaining information on entry routes, colonization pathways, possible host range expansion and adaptation of pests to new environments help to prevent new invasions to occur or to limit spread and subsequent plant damages. Also how detailed understanding prey-predator interactions are needed to efficiently control new pests. Finally, I discuss how invasion biology serves as a key component of regulatory plant security systems targeted to protect plant resources from invasive species threatening crops and agricultural commodities.

Keywords: pests, agroecosystems, biological control.

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THE USE OF *TRICHODERMA HARZIANUM* AS A BIOLOGICAL CONTROL AGENT FOR *SAGITTARIA GUAYANENSIS* (DUCKWEED) FOUND IN RICE CULTIVATION BY IN VITRO METHOD

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Abstract: *Trichoderma* readily colonizes plant roots and some strains are rhizosphere competent i.e. able to grow on roots as they develop. *Trichoderma spp*. also attacks, parasitize and otherwise gain nutrition from other fungi. They have evolved numerous mechanisms for both attack of other fungi and for enhancing plant and root growth. Different strains of Trichoderma control almost every pathogenic fungus for which control has been sought. However, most Trichoderma strains are more efficient for control of some pathogens than others, and may be largely ineffective against some fungi. (Yedidia et al., 1999). An experiment was performed with *Trichoderma harzianum* to test whether it has an effect on the growth of *Sagittaria guayanensis* commonly known as "rice field duckweed." The duckweeds were collected from a rice field in Black Bush Polder, labelled and placed into pots; the pots were placed in the poly house. The plants were then inoculated with *T. harzianum* at different concentrations (20ml, 30ml, 40ml and 50ml per 4 l of water respectively). A completely randomised experimental design was used and the treatments were replicated three (3) times. The plants were inoculated for three (3) weeks where they were checked on a weekly basis for the leaf, stem and root growth. The growth data collected was subjected to ANOVA and the means were tested by LSD. The results demonstrated that T. harzianum had a biological effect on the growth of duckweed. There were differences between the untreated control and the treatments for all the growth parameters after inoculation.

Keywords: Trichoderma spp, duckweed, biological control

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VEGETABLE-OIL BASED PESTICIDES IN THE MANAGEMENT OF THE RUST (*HEMILEIA VASTATRIX*) AND SECONDARY PESTS IN COFFEE (*COFFEA ARABICA*)

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Abstract: Significant losses to the national economy and the productive sector by massive defoliation caused by the fungal disease of coffee leaf rust (*Hemileia vastatrix*, Basidiomycetes: Pucciniaceae) have led many producers to leave the land or replace the coffee with crops not suitable for areas with a slope causing an environmental impact. Chemical control of the disease increases production costs considerably and constitutes a threat to the environment in vulnerable areas that serve as a reservoir of water for people and economic activities of the plains. This makes the search for viable solutions necessary. A field trial was conducted in an established coffee plantation with presence of coffee rust, located in Rancho Arriba, Ocoa Province, using a Mitscherlich experimental design with repetitions located perpendicular to a gradient with respect to luminosity (shadow). The objective was to compare the efficiency of 3 applications of two organic fungicides based on vegetable oils from rosemary, sesame, clove, thyme (only T3) and others (T3, 2.64ml/l; T4, 0.66ml / l) with a synthetic-based 24% (SC) of copper sulfate pentahydrate (T5, 8.8ml/100l) for the management of this disease, compared with an absolute check (T1) and another relative control (T2), an organic fertilizer based on cod waste which was added (4.54g/l) to all treatments except to T1. By means of a phytosanitary evaluation, the main problems of the plantation could be identified. A sampling method was developed based on the classification in degrees of damage resulting an index of severity that allowed to calculate the mean estimated affected leaf area (MEALA) by rust diseases and also two minor problems, a fungal disease called 'leaf spot of coffee' (*Mycena citricolor*, Basidiomycetes: Mycenaceae) as well as for a moth, the 'coffee leaf miner' (*Perileucoptera coffeella*, Lepidoptera: Lyonetiidae). The MEALA of 8 (for rust) or 5 evaluation dates, respectively, and average indices, showed in the first two cases highly significant differences ($P < 0.01$ ** to 0.0001 ***) between the similar values for fungicides (T3-T5) and the controls (T1 and T2) on one side (rust, leaf miners), and also among the controls (T1 and T2) on various dates for rust, on the other. In the case of leaf spot of coffee' there was little incidence but significant differences ($P < 0.05$ *) just for one out of 5 evaluation dates and the overall average between the fungicides (T3-T5) and the absolute control (T1). In addition, the effects of these fungicides on parameters of productivity, quality and type of damage were evaluated during the first harvest. It allowed us to detect that much of the damaged grains were affected by 'coffee berry borers' (*Hypothenemus hampei*, Coleoptera: Scolytidae) and the 'coffee berry disease' (*Colletotrichum kahawae*, Sordariomycetes: Glomerellaceae). The statistical analysis of the obtained values did not detect significant differences between the treatments concerning fruit categories. The vegetable oils can serve as a viable organic alternative for phytosanitary management programs in coffee achieving similar results as a cupric fungicide, even certified for organic agriculture. However, in severe attacks of rust, its effects may be considered insufficient.

Key words: *Coffea arabica*, fungicides, vegetable oils, *Sesamum indicum*, *Syzygium aromaticum*, *Rosmarinus officinalis*, *Thymus vulgaris*, *Mycena citricolor*, *Perileucoptera coffeella*, *Hypothenemus hampei*, *Colletotrichum kahawae*, Dominican Republic.

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PRODUCTION OF YARD-LONG BEAN (*VIGNA SINENSIS* VAR. SESQUIPEDALIS) USING THREE PLANT SPACINGS IN A CONVENTIONAL AND ORGANIC FARMING SYSTEM

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Abstract: A study was conducted to compare the production of yard-long beans using a conventional and organic farming system. The experiment was carried out at a farmer's field at Uitkijk, Saramacca, which is situated in the young coastal plain of Suriname. The experiment was set up as a Complete Randomized Block Design with a 3x 3 factorial arrangement. The two factors in the experiment were fertilization (control, organic and synthetic) and row plant spacing (25, 40 and 55 cm). The nine treatment combinations included: control with plant spacing 25, 40 and 55 cm; organic with plant spacing 25, 40 and 55 cm and synthetic with plant spacing 25, 40 and 55 cm. Fertilizers were applied to the plots, except to the control. Organic fertilizer was applied on a basis of 1 kg/m2 and NPK 12-12-17 was applied to the fertilizer plots in the amount of 50 g/m2 plus 20 g of double super phosphate. Fertilizer was applied to the plots before sowing, and the second application took place two weeks after sowing. Data were collected and analyzed with MS excel and SPSS statistics. Analysis of Variance (ANOVA) indicated that during the first four weeks there were significant differences ($P< 0.05$) in plant height among the treatments. There were also significant differences ($P< 0.05$) in planting method and row plant spacing on the weight, length and number of harvested pods. The results indicate that spacing and fertilization had an effect on yield of yard-long beans. Based on the results it can be stated that the best planting method for yard-long beans is a plant spacing of 40 cm in an organic farming system. When cultivated with NPK (12-12-17), a plant spacing of 55 cm and higher should be used.

Keywords: organic farming system, chicken manure, plant spacing, yard-long bean production, conventional farming system, humid tropics.

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ASSESSING THE PROFITABILITY OF GUAVA (*PSIDIUM GUAJAVA* L.) PRODUCTION IN SOUTH FLORIDA UNDER RISK AND UNCERTAINTY

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Abstract: This contribution assesses the profitability of operating a five-acre Thai guava orchard in South Florida incorporating yield and price risk. A stochastic analysis was used to examine the probability of the growers making a loss or receiving 25%, 50% and 75% return on their investment. The results indicate that there was a slight chance (2%) that the grower could end up receiving a negative return (loss). However, there was a 92%, 77%, and 50% chance that the grower would exceed the targeted 25%, 50%, and 75% return on investment, respectively.

Keywords: Thai guava, stop light chart, stochastic analysis, risk and uncertainty, simulation, GRKS

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PHYSIOLOGICAL EFFECTS OF ARBUSCULAR MYCORRHIZAL APPLICATION ON WATER STRESS IN TOMATO SEEDLINGS

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Abstract: Water stress occurs in plants when water supply to the roots is limited or transpiration rates are too intense. Water deficiency can have morphological and physiological effects on plants including reduction in the number of leaves, the size of the root, stem, fruit and yield amount as well as reduced photosynthetic activity and Rubisco production. Water stress has been a major limiting factor in crop production since early agricultural days. Consequently, the ability of plants to withstand such stress is of immense economic importance. *Mycorrhiza* results from a symbiotic association between a soil fungus and a plant root. The fungus gains carbohydrates from the host plant and the hyphal network of mycorrhizal roots greatly increases access to water and inaccessible minerals, and increase resistance to pathogens. Mycorrhizal inoculation of plants is the introduction of soil fungi into plant tissue in an effort to improve plant growth especially in water stressed areas. We studied the effect of mycorrhizal inoculation on tomato (*Solanum lycopersicum*) growth in water stressed and well watered situations over a nine week period. The results showed that mycorrhizal plants performed better for growth parameters regardless of the water regime used, except for root biomass under water stress conditions. Only inoculated plants under well watered conditions showed a statistical significance for plant biomass.

Keywords: Water deficiency, water stress, *Mycorrhiza, Solanum lycopersicum.*

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FORESIGHT STUDY ON GUADELOUPEAN AGRICULTURE

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Abstract: While greening agriculture has emerged as a new paradigm in agricultural research and development, one of the UNEP's findings is that transitions of agricultural systems away from "Business-as-usual" are required if negative externalities of agriculture are to be reduced. To make these transitions effective, actors collectively need to be able to anticipate the future so that planning can be implemented and steps taken for action. As decision support tools, foresight studies can help build this representation of the future and identify possible avenues to meet the desired ones. We have implemented a foresight study on agriculture in Guadeloupe (French West Indies). We adopted a participatory approach and a scenario based methodology. Fifteen experts were chosen on the basis of their diversity of disciplinary and professional backgrounds, their knowledge of, and implication in the territory, as well as for their geographical representativeness. Additionally, two non-Guadeloupian experts were selected as outsiders both from a geographic and a conceptual point of view in order to help us broaden our thinking horizons. Several workshops, of which two have already been held, are planned with this group of experts. Steps of the methodology include: 1/building up a common representation of the system at stake; 2/identifying the past tendencies of the variables that define and influence the system; 3/inferring hypotheses on their future evolution and 4/ building up the "Futuribles" (i.e. the possible scenarios for the future of the system). The scope of the foresight study is the year 2040. Such a pace of time allows taking breaks into account in the analysis of past tendencies and liberating the discourse of participants. Among the first findings are the fact that agriculture in Guadeloupe needs to be re-defined to better take into account small holders into agricultural policies, and that adequate mechanisms needs to be identified to help both agricultures (conventional mainstream agriculture and small scale agriculture) meet an evolving demand while being sustainable.

Keywords: Green agriculture, UNEP, Guadeloupe.

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A PRELIMINARY INVESTIGATION ON THE FEASIBILITY OF AQUACULTURE IN THE INDIGENOUS COMMUNITY OF KWAMALASAMUTU, SURINAME

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Abstract: This contribution presents the results of a preliminary investigation on the feasibility of aquaculture projects in the vicinity of Kwamalasamutu, a Trio Indigenous community in Suriname. The research was conducted between February 6 and March 14, 2014. A local NGO, Amazon Conservation Team-Suriname (ACT-S) provided logistical and financial support for the research. A total of 69 fish species were documented representing 5 fish orders: Characiformes, Gymnotiformes, Siluriformes, Perciformes and Myliobatiformes and 23 fish families. Thirty-eight fish species were known as common food fish by local indigenous people and more than 25 species were potential ornamental fish. Endemic species like the notorious stingray Potamotrygon boesemani were observed and several Corydoras spp. where collected. Six main bodies of water in the vicinity of Kwamalasamutu were sampled for water quality. At these sites, five water quality parameters were measured: pH, temperature, dissolved oxygen, conductivity and turbidity. The water in the creeks was overall slightly more acidic, colder and lower in oxygen than in the rivers. Several potential aquaculture sites near Kwamalasamutu were identified, including a creek site where an aquaria center could be established and two creek sites amenable to cage system aquaculture. Thirty-two community participants were interviewed for this study (62.5% male, 37.5% female). All of the participants stated that they consume fish and 43.8% consume fish daily. More than 70% observed that there has been a decrease in the fishing pattern (fish catch) and 75% expressed interest in aquaculture (43.8% male, 31.2% female). Most of them (96.6%) would definitely visit an aquaculture center with ornamental fish in Kwamalasamutu and 31.3% would want to work in the center. It appears there is sufficient interest in the community about aquaculture and there is sufficient manpower for a successful aquaculture project in Kwamalasumutu warranting further investigation.

Keywords: aquaculture, Kwamalasamutu, Amazon Conservation Team-Suriname (ACT-S), ornamental fish, freshwater fish species, water quality.

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EFFECT OF INTERCROPPING CABBAGE WITH TOMATO FOR POTENTIAL CONTROL OF PEST OCCURRENCE ON CABBAGE (*BRASSICA OLERACEA* L. VAR. *CAPITATA)*

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Abstract: Conventional farming and mono-cropping systems are contributing to depletion of natural resources and are causing environmental problems. On the other hand, intercropping increases the diversity in an agricultural production system and has been used for centuries for manipulating insect pests on different crops. Cabbage cultivation in Suriname is vulnerable to many pests and diseases and requires a lot of attention to control them. The cultivation of cabbage in Suriname takes place on a small scale basis by farmers in the coastal region. Pest infestation normally leads to reduction in market value and in some cases to total crop failure. The aim of this study was to evaluate the effect that intercropping of cabbage with tomato has on the pest occurrence and pest population on cabbage and on the production of cabbage. For this experiment, a Complete Randomized Block Design was used consisting of five treatments in duplicate. The treatments included (1) tomato (control), (2) cabbage (control) two rows cabbage to one row tomato; three rows cabbage to one row tomato; four rows cabbage to one row tomato. Data were collected and registered on insect pests, plant damage and yield. Preliminary results are indicating that tomato plants have an effect on the pest occurrence of cabbage and can act as host plant for various insect pests occurring on cabbage. Data are suggesting that the treatment with three rows of cabbage to one row of tomato is giving the best results in terms of pest management control and cabbage production.

Key words: cabbage, tomato, intercrop, organic production, cabbage pests, natural enemies.

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EFFECT OF BIOCHAR APPLICATION ON SOIL QUALITY AND PAK-CHOI (*BRASSICA RAPA* L. VAR. CHINENSIS) PRODUCTION

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Abstract: Biochar obtained from carbonization of biomass through pyrolysis is a potential soil amendment and carbon sequestration medium. Biochar in agriculture is important because both its chemical and physical properties are known to improve soil fertility. The aim of this study was to evaluate the potential use of traditionally produced charcoal (biochar) as a growth medium in raised beds on soil quality, and to evaluate its effect on plant growth. The efficiency of three levels of biochar (0, 5 and 10 ton/ha), with and without charging the biochar, on the growth of Pak-choi was investigated. The charcoal used in this research was pyrolyzed at 250°C. Results show that biochar significantly affected the total CEC, carbon content and plant production. ($p < 0.05$). In the first pak-choi field trial, the effect of biochar was not significant among the treatments, while in the second field trial significant differences among treatments were found ($p < 0.05$). The greatest biomass increase was found with 10 ton/ha biochar during the second trial. In conclusion, it can be stated that biochar has a very promising potential to be implemented as a practice to further develop sustainable agriculture production systems. In Suriname, biochar, as a sustainable practice, can also increase the production by small scale farmers. In addition, it is an option to add value to waste biomass.

Keywords: biochar, charcoal, bockchoy, pyrolyzation

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PRODUCTION OF YARD-LONG BEAN (*VIGNA SINENSIS VAR. SESQUIPEDALIS*) USING THREE PLANT SPACINGS IN A CONVENTIONAL AND ORGANIC FARMING SYSTEM

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Abstract: A study was conducted to compare the production of yard-long beans using a conventional and organic farming system. The experiment was carried out at a farmer's field at Uitkijk, Saramacca, which is situated in the young coastal plain of Suriname. The experiment was set up as a Complete Randomized Block Design with a 3x 3 factorial arrangement. The two factors in the experiment were fertilization (control, organic and synthetic) and row plant spacing (25, 40 and 55 cm). The nine treatment combinations included: control with plant spacing 25, 40 and 55 cm; organic with plant spacing 25, 40 and 55 cm and synthetic with plant spacing 25, 40 and 55 cm. Fertilizers were applied to the plots, except to the control. Organic fertilizer was applied on a basis of 1 kg/m^2 and NPK 12-12-17 was applied to the fertilizer plots in the amount of 50 g/m^2 plus 20 g of double super phosphate. Fertilizer was applied to the plots before sowing, and the second application took place two weeks after sowing. Data were collected and analyzed with MS excel and SPSS statistics. Analysis of Variance (ANOVA) indicated that during the first four weeks there were significant differences ($P< 0.05$) in plant height among the treatments. There were also significant differences ($P< 0.05$) in planting method and row plant spacing on the weight, length and number of harvested pods. The results indicate that spacing and fertilization had an effect on yield of yard-long beans. Based on the results it can be stated that the best planting method for yard-long beans is a plant spacing of 40 cm in an organic farming system. When cultivated with NPK (12-12-17), a plant spacing of 55 cm and higher should be used.

Keywords: organic farming system, chicken manure, plant spacing, yard-long bean production, conventional farming system, humid tropics

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PRELIMINARY STUDY ON THE FEASIBILITY OF DEVELOPING BAMBOO PRODUCTS WITHIN THE CONTEXT OF SOCIO-ECONOMIC AND CULTURAL REALITY IN KWAMALASAMUTU

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Abstract: Bamboo is an ancient woody grass native to the tropical forest in the world. It belongs to the family, Poaceae (Gramineae), subfamily Bambusoideae. Bamboo is a fast growing natural resource and one of the most popular non-wood forestry products (NWFPs). In the last twenty years bamboo has also gained the popularity as an agro-forestry resource, “poor man’s timber”. In the interior of Suriname, the village Kwamlasamutu is known as a village with a lot of bamboo. The Amazon Conservation Team Suriname strives to get a sustainable generation for the indigenous people in Kwamalasamutu combined with protection of the forest. ACT-S is an organization which implements field based studies utilizing local forest resources with the potential to provide economic and sustainable livelihood benefits to local communities The organization believes that there is a great potential for the community to process bamboo. The indigenous people do not really use bamboo as a resource. A preliminary study on the feasibility of developing bamboo products within the context of socio-economic and cultural reality in Kwamalasamutu was conducted to attain better understanding of bamboo uses and the interest of the indigenous people for developing bamboo products. The research methodology included a bamboo inventory, assessment of potential bamboo products, and a pilot study in using bamboo products. Results reveal that (1) Kwamalasamutu has different bamboo species, (2) there are species found that have never been described before for Suriname, (3) woody bamboo species are known to have the potential for developing bamboo products, and (5) the indigenous people are not so aware of their bamboo potentials.

Keywords: Bamboo species, bamboo products, Kwamalasamutu, Amazonian Conservation Team Suriname.

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EVALUATING THE EFFECT OF THE BIOLOGICAL CONTROL AGENTS *TRICHODERMA* SP. AND *BURKHOLDERIA CEPACIA* TO CONTROL *FUSARIUM OXYSPORUM*

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Abstract: *Fusarium* wilt is caused by the soil-borne fungus *Fusarium oxysporum*. In Suriname *Fusarium* spp. affects several crops including tomato. The use of fungicides generally does not provide satisfying results. Therefore, it is important to study the management of the soil-borne pathogen *Fusarium* spp. with effective biological control agents. For this research two agents were used: *Trichoderma* sp. and *Burkholderia cepacia*. The research consisted of an *in vivo* and an *in vitro* study. In the *in vivo* study, the efficacy of *Trichoderma* to control *F. oxysporum* infection of tomato plants in greenhouse conditions and in the open field was tested. Furthermore, a tomato seed coating experiment was carried out in the greenhouse to test the efficacy of *Trichoderma* to control *F. oxysporum* infection. Data were statistically analyzed with ANOVA. The *in vitro* study consisted of two experiments. In the first experiment the inhibitory effect of *Trichoderma* on growth of *F. oxysporum* was tested. The aim of the second experiment was to test the antagonistic effect of *Burkholderia cepacia* on the growth of *F. oxysporum*. Results from the *in vivo* study showed that *Trichoderma* was able to significantly suppress *F. oxysporum* infection of tomato plants, which were planted in soil, being artificially infested with *F. oxysporum*. However, results from the seed coating experiment showed that *Trichoderma* could not suppress *F. oxysporum* infection of tomato plants, of which the seeds had been coated with *Trichoderma* and then planted in soil that was artificially infested with *F. oxysporum*. Results from the *in vitro* study showed that *Trichoderma* was also able to inhibit growth of *F. oxysporum* on Potato Dextrose Agar in petridishes. The culture of the bacterium *Burkholderia cepacia* that was used for the experiment did not show an antagonistic effect on the growth of *F. oxysporum*.

Keywords: *Fusarium oxysporum*, *Trichoderma*, *Burkholderia cepacia*, tomato.

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CONTROL OF THE BROADLEAF WEEDS *CISSUS SICYOIDES* (BUN-ATI-MAMA) AND *MONTRICHARDIA ARBORESCENS* (MOKO-MOKO) WITH THE HERBICIDE GLYPHOSATE IN THE BANANA PLANTATION OF STICHTING BEHOUD BANANEN SECTOR (SBBS)

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Abstract: The banana company, SBBS, now FAI NV, has been applying a 2% dosage of the herbicide glyphosate every six weeks for many consecutive years to control weeds. The company is GLOBAL-G.A.P. certified and is still encountering difficulties to control particular weeds, including *Cissus sicyoides* (bun-ati-mama) and *Montricharida arborescens* (moko-moko). Therefore, SBBS requested a field study to test the efficiency of different glyphosate dosages to determine which concentrations could effectively control the above-mentioned weeds. In addition, the company was interested in knowing whether adding the non-ionic surfactant Triton X-45 to glyphosate would improve its efficiency in controlling the weeds. The experimental design was a split-plot design with three replications. The main factor was the surfactant at two levels: non-surfactant and surfactant. The subfactor was glyphosate application at five levels: 0, 1, 2, 3 and 4%. Observed parameters were leaf mortality, regrowth and percentage of dead stems. Data was statistically analyzed with ANOVA and Chi-square test. In addition to the field study, a laboratory assay was also conducted. The laboratory assay was a preliminary study which aimed at investigating if the weed *C. sicyoides* which occurs in SBBS plantations has started to develop resistance against glyphosate. This was done by measuring the amount of shikimic acid in *C. sicyoides* leaves by means of a spectrophotometer. Results from the field study showed that adding the surfactant Triton X-45 to glyphosate did not improve the efficiency of glyphosate. Throughout the study, the 3% and 4% glyphosate dosages were generally more effective in controlling both weeds. The shikimic acid test indicated that it is likely that the *C. sicyoides* weed population at SBBS is starting to develop resistance against glyphosate.

Keywords: glyphosate, *Cissus sicyoides, Montrichardia arborescens*, leaf mortality, regrowth, shikimic acid.

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EVALUATION OF THE BAKING PROPERTIES OF BREAD, ENRICHED WITH RICE BRAN

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Abstract: Rice bran is a by-product that is produced when brown rice is milled to white rice. Due to its good properties as a valuable source of nutrients, B vitamins, minerals and its ability to reduce serum cholesterol and the risk of heart disease, rice bran has become popular for use in food products. In this study, stabilized rice bran (SRB) was incorporated in bread at two levels. The baking properties of the bread and its acceptance by consumers were evaluated. Three different breads (Bread A, B and C) with different rice bran levels were made. Bread A consisted of 10% SRB and 90% whole wheat flour (WWF), and bread B consisted of 15% SRB and 85% WWF. Bread C was a white bread with 15% SRB and 85% white flour. No gluten was added to the dough. The results of this study showed that the different types of bread had acceptable baking properties. This indicated that higher SRB levels could possibly be used. Since rice bran does not contain gluten, adding gluten to the dough may be necessary to prevent the formation of cracks on the surface of the bread. From the consumer feedback we found that whole-wheat bread was preferred above white bread. The white bread tended to have a strong typical scent of rice bran and a sour taste. The scent of rice bran was less in whole-wheat bread.

Keywords: Rice bran, baking, cholesterol, gluten

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COMPARATIVE COASTAL BIRD DIVERSITY AND ABUNDANCE OF THREE ESTUARINE AREAS WITH DIFFERENT HEALTH STATUS IN SURINAME

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Abstract: Coastal bird activity along the Surinamese coast was compared in relation to the mangrove ecosystem health. Coastal bird diversity and abundance was assessed in three estuarine areas of varying health status along the Suriname coastline. While the species diversity was almost the same for the three sampled areas, there was a significant difference in number of birds observed at each area. The *Weg naar zee* area had the least number of observed coastal birds, followed by the Matapica area; with the North Coronie area containing the highest number of birds. The mangrove ecosystem at the *Weg naar zee* area was the most damaged and highest at risk. The Matapica and the North Coronie ecosystem area were the least damaged, with North Coronie showing the best health and biodiversity. The results show that the coastal bird abundance is positively correlated to the health status of the ecosystem. This is confirmed by the Shannon-Weaver index for each location. The Shannon-Weaver index for the *Weg naar zee* area was highest, followed by the Matapica area, while the North Coronie area had the lowest index. This study also confirmed that the coastal bird activity is a reliable bio-indicator for the health status of their habitats: the mangrove forests.

Keywords: Coastal bird, mangrove, ecosystem, biodiversity

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AGRONOMIC TRAITS OF FOUR SURINAMESE CASSAVA ACCESSIONS COMPARED TO THE COLOMBIAN VARIETY CM6740-7

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Abstract: The Colombian variety CM6740-7 and four accessions selected from the CELOS cassava (*Manihot esculenta* Crantz.) *ex situ* field genebank are being further evaluated at the Tijgerkreek West experimental open field in Saramacca. The area has been tilled in well drained, 7 m wide, cambered beds consisting of loamy, fine textured sand, characteristic for the sandy soil sites of this young coastal and cultivated area. The characterization focused on valuable agronomic traits with regard to the mechanized production of roots with white parenchyma followed by the processing into flour or starch. Stalks with five nodes were cut from primary and secondary stems from healthy, one year old parental plants and were planted horizontally at a density of 10,000 plants ha^{-1}. The first growing cycle started in August 2014. The experimental layout allowed for harvests and observations after growing seasons of 10, 12 and 14 months, respectively. Traits influencing the multiplication rate and the suitability for mechanized planting and harvesting will be characterized by measuring related stem, node, branching and root system characteristics. Decision making traits for processing will be measured, analyzed or calculated, such as (commercial) root yield, harvest index, dry matter content, specific gravity, cyanide and starch content and post harvest deterioration. The vulnerability to stress caused by occasional occurring soil water logging, drought, diseases and competition will be observed and assessed. The most beneficial growing season length for each accession and adaptability to different cultivation calendars can be evaluated. The relationship between measured dry matter content (oven dry method) and specific gravity (balance method) will be calculated. In general, after two subsequent growing cycles, the data will allow to choose for a more appropriate genetic material and as such will support further development and innovation of the Surinamese cassava root production sector and specific industrial processing chains.

Keywords: Cassava, agronomic, Colombian variety CM6740-7.

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THE EFFECT OF SUNATO 540FS AGAINST THE RICE WHORL MAGGOT (*HYDRELLIA SP.*)

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Abstract: A field experiment was conducted at the Anne van Dijk Rijst Onderzoekscentrum Nickerie (SNRI/ADRON) to evaluate the effectiveness of Sunato 540FS, a broad-spectrum seed treatment insecticide, used in the control of whorl maggots. The results showed that whorl maggot damage in the treated plots was significant lower for at least two weeks after sowing. After 14 days the number of plants/m^2 in the untreated plots started to decrease resulting in a significant difference with the treated plots at 21 DAS. Except for tillering, the plant development was also significantly better for the treated plots, which resulted in a significant higher number of panicles/m^2 and yield.

Keywords: Anne van Dijk Rijst Onderzoekscentrum, Sunato 540FS, insecticide

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THE DETERMINATION OF THE LEVEL OF RESISTANCE AND TOLERANCE TO CASSAVA FROG SKIN DISEASE WITHIN SEVEN IN SURINAME COLLECTED CASSAVA ACCESSIONS

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Abstract: Cassava (*Manihot esculenta Crantz*) is the fourth most important staplefood in the developing countries after wheat, rice and maize, being widely grown in the Caribbean. The stronger focus on food security has raised the interest in cassava. Cassava Frog Skin Disease (CFSD) is a serious threat to growing cassava as it can reduce the weight of the storage roots by 90% or more. The disease is caused by complexes of one or more viruses and eventually a phytoplasma. Until 2012, CFSD had been reported in Argentina, Brazil, Colombia, Costa Rica, Panama, Peru, Venezuela and Suriname and could spread to other countries in the Caribbean. Propagation is done only by cuttings. Therefore, the pathogens can easily be transferred. Consequently, the disease spreads rapidly if no adequate sanitary measures are taken. Living plants cannot be cured from virus- and phytoplasma-diseases. The only method of protecting crops is through preventive measures of which resistance is highly preferred and easily practiced by farmers. The C.E.L.O.S. cassava collection contains 111 accessions collected in Suriname of which 72 could be resistant/tolerant. Of seven of the most promising accessions with good agricultural properties the level of resistance/tolerance to CFSD will be determined by measuring root weights and severeness of peel symptoms in a field trial with randomized block design and four replications. In this trial we expect to find tolerant and maybe even CFSD resistant cassava that can be used in breeding programmes to stimulate sustainable development of the cassava sector in Suriname.

Keywords: cassava; CFSD, disease resistance, disease tolerance, food security

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RESIDUAL LEVELS OF FURAN IN SOME CARIBBEAN FOOD AND ITS KINETIC INTERACTIONS WITH LOW MOLECULAR WEIGHT BIOLOGICAL REDUCTANTS

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Abstract: The potential carcinogenic effects of furan on humans and the recent discovery of furan in commercial foods have stimulated tremendous interests; prompting the investigation of the levels generally found in food across the world. The concern of the scientific community is whether furan may cause cancer in humans through long-term exposure to very low levels. Determining the levels of furan found in food and identifying precursors naturally present in food justifies research in obtaining valuable information to alleviate this concern. Caribbean foods that are both commercial and home-prepared were selected for determination of residual levels of furan. The method applying Purge and Trap Gas Chromatography Mass Spectrometry (P&T/GC/MS) was validated and used to quantify residual levels of furan in some Caribbean fruit juices. Furan was quantified in commercial juice samples with a limit of detection (LOD) of 0.2 ppb, limit of quantification (LOQ) of 0.7 ppb and recovery of 97-103% with a RSD $\leq$ 10%. The levels of furan found in the commercial juice samples were below the LOQ. The method of Headspace Gas Chromatography Mass Spectrometry (HS/GC/MS) is currently being employed to detect and quantify the levels of furan in a wide range of Caribbean foods, such as coffee, milk products, soups, meats, fruits, pastries and snacks. The volatility of furan makes the study of its kinetic interactions very challenging and as a result different methods are being explored. To date, the kinetics of the interactions of furan with low molecular weight biological reductants such as glutathione, and the interactions of glutathione with model furan metabolites, such as butyraldehyde, were investigated spectrophotometrically.

Keywords: Furan, Carcinogenic, Caribbean foods.

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IMPACTS OF AGRICULTURAL ACTIVITIES ON FISH COMMUNITIES

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Abstract: Data and studies on Coastal Biodiversity in Guyana, particularly on coastal agro-ecosystems, are highly inadequate and limited. Most agricultural activities are concentrated on the Low Coastal Plain of Guyana and this sector contributes significantly to Guyana's economic growth. This study assessed the impacts of agricultural activities: commercial rice and sugar-cane farming on fish communities within two of the dominating areas: Mahaicony and Enmore both located on the Low Coastal Plain of Guyana. The researcher hypothesized that agricultural activities would adversely affect fish species within the disturbed sites defined as areas highly influenced by rice and sugar cane cultivation by lowering diversity and abundance as compared to undisturbed sites defined as areas that are more pristine in nature. Methodically, a total fourteen sites were sample in both locations where nine were disturbed and five were undisturbed. Fish collection was done by the drag-seine method. At each site, the water quality parameters: Turbidity, Temperature, Dissolved Oxygen, pH, Phosphate and Total Kjeldahl Nitrogen (TKN) were assessed. This study found 525 fishes from 6 orders, 14 families and 25 genera from all the sampled sites. Anova: Single factor tests confirmed that there were no significant differences among disturbed sites and undisturbed sites for the water quality parameters tested, except for phosphates and Total Kjeldahl Nitrogen (TKN), which showed significant differences between the two types of sites. Analysis showed that undisturbed sites had a greater diversity of 2.165 compared to disturbed sites at a value of 2.016.

Keywords: Coastal Biodiversity, Guyana, fish communities, rice, sugar.

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EFFECT OF BIOSTIMULANTS ON THE YIELD PERFORMANCE OF ORGANICALLY-GROWN OKRA CULTIVARS IN THE U.S. VIRGIN ISLANDS

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Abstract: Okra is one of the widely grown vegetable for the commercial market in the United States Virgin Islands and the rest of the Caribbean. Plant biostimulants or agricultural biostimulants include diverse substances and microorganisms that are derived from commercial marine algae extracts, enhance plant growth of fruits and vegetables. Plants of eight cultivars of okra (*Abelmoschus esculentus*) treated weekly with Stimplex® (5 ml/L) liquid seaweed extract of (*Ascophyllum nodosum*) and Biozest® (100 mL/5L) crop biostimulants as foliar spray to assess yields under the effect of biostimulants. Half of the plants in a row (5plants) sprayed weekly and half of the plants (5plants) were untreated control. Eight cultivars of okra ca. Clemson Spineless 80, Red Burgundy, Clemson Spineless, Jambalaya, Red Velvet, Annie Oakley II, Perkins Mammoth and Chant were investigated. The experimental design was a randomized complete block with 3 replications consisted of rows spaced 3' apart and spaced 2' between the plants within a row. Plots were managed with organic cultural practices. Results showed that Biozest® treated plants of most of the cultivars responded positively. Marketable yields were higher in Biozest® treated plants of Clemson Spineless 80 (0.5%), Annie Oakley II (27.9%), Perkins Mammoth (49%), Jambalaya (41.2%), Chant (16%) and Red Burgundy (60%) than untreated control. Higher marketable yields were obtained in Stimplex® treated plants of Jambalaya (62%), Red Burgundy (58%) and Perkins Mammoth (30%), than untreated control. Cultivars produced lower or non-significant yields in Clemson Spineless 80, Clemson Spineless, Red Velvet, Annie Oakley II and Chant. The results show that biostimulants may increase yields in okra, however, further research trials are needed to fully explain the effects of biostimulants in commercial production.

Keywords: Vegetables, Crop biostimulant, Organic, Production, Yield

Introduction

Okra is a versatile warm-season best known vegetable crop produced in southern region of United States. Okra is grown commercially in Georgia, South Carolina, Tennessee, Alabama, Texas, California, and Florida. Most southern states cultivate enough okra to make available for local demand. . There are ≈15,000 acres of land (6,000 ha) of okra produced annually in the United States. It is a highly nutritive value and easy to cultivate vegetable crop. These varieties perform differently under the diverse conditions or nutrition. Tender green pods are consumed as a vegetable and used as a thickening agent in the soups. Well drained soil with organic matter soil is suitable for production of okra. This can be achieved by applying animal manures or incorporating green manure crops (Colditz and Barber, 1975). Moreover, the biostimulants adds to the better growth and development of okra in organic management system. There are number of varieties of okra available in the market for commercial production in organic crop management.

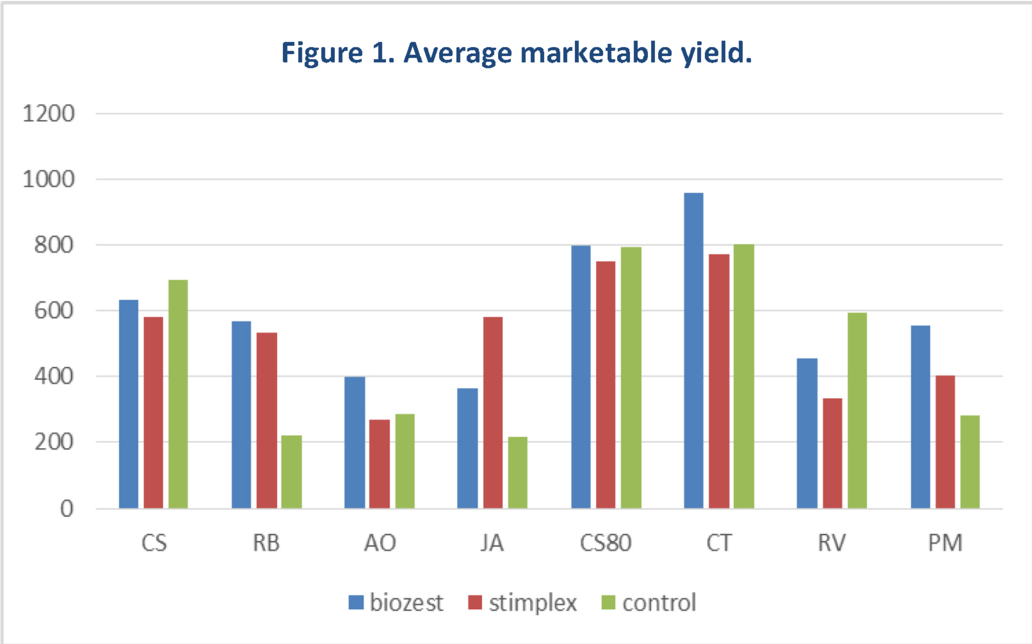
The biostimulant federation defined biostimulants as "materials, including microorganisms, that are applied to plant, seed, soil or other growing media that may improve the plant's capability to assimilate useful nutrients, or deliver benefits to plant development" (Calvo et. al. 2014). Marine bioactive elements extracted from seaweed like Stimplex and biozest are currently used in organic farming, in order to avoid extreme application of fertilizers and improving the uptake through the roots or leaves. So, number of characteristically determined products are utilized as development promoters or biostimulants on vegetables, regardless of the fact that their components of activity are not still now totally illuminated. Among them, seaweed products are embedded as permissible organic (natural) manures (Trinchera et. al. 2014). Stimplex is one of biostimulant derived from the seaweed extracts. Stimplex is best used in drip irrigation for fertigation and applied after the 2 weeks of emergence and then after every 1 week until end of blooming in okra crop. Effects of the biostimulants have been testified to increase the production, upsurge the efficiency of nutrient use and resistance to various factors and biotic abiotic stress. Study conducted on pepper (*Capsicum annuum* L.) to explore the effect of natural biostimulants on yield and quality parameters of fruits and they got significant results in terms of yield and other parameters. There was increase observed in the pigment content of leave with the application of biostimulant results in the higher total and marketable yields of treated pepper cultivars as compared to their controls. The results indicated that natural biostimulants had a synergistic effect on the vitamin C and total phenolic contents in pepper fruits. The antioxidant activities were also noticeably higher ($P < 0.05$) in treated plants excluding the phenolic content (Parađikovic et. al. 2011). Thus the use of biostimulants is considered as good approach to increase the overall production of the crop.

Materials and Method

Eight cultivars of okra ca. Clemson Spineless 80, Red Burgundy, Clemson Spineless, Jambalaya, Red Velvet, Annie Oakley II, Perkins Mammoth and Chant were investigated. The experimental design was a complete randomized block with three replications. The trial was conducted from 7 October, 2013 through 27 November, 2013. Crops were grown using National Organic Program (NOP) standards and permitted practices. Seeds were planted in 72-cell trays containing farmer produced organic compost at the University of the Virgin Islands on St. Croix, greenhouse reared, and transplanted into the field 21 days after germination. There were 36 plants per plot for each variety for a total of 864 plants in the field. Data was collected from ten plants in the center row of each plot. The tender pods of okra plant are harvested after every two days and the data of total yield, total number of fruits per plant has been calculated. After the complete period of crop production the data was compiled and analyzed by using SAS and the significant results were calculated.

Results and Discussion

Significant results were observed from the application of the biostimulants in okra. As shown in figure 1 Average marketable yield for Clemson spineless 80, chant, Red burgundy, Annie Oakley and Perkins mammoth is higher in the biozest treated plants and Clemson spineless and red velvet have higher average marketable yield with the stimplex treatment. On the other hand, in case of average yield per plant the effect of both stimulants on varieties Clemson spineless, Clemson spineless 80 and red velvet were not significant. However, in other varieties on an average biozest treated plants performed well in terms of average yield per plant. We did not find any significant differences in the average fruit weight of the okra varieties in stimplex, biozest and control plants (Table 1).



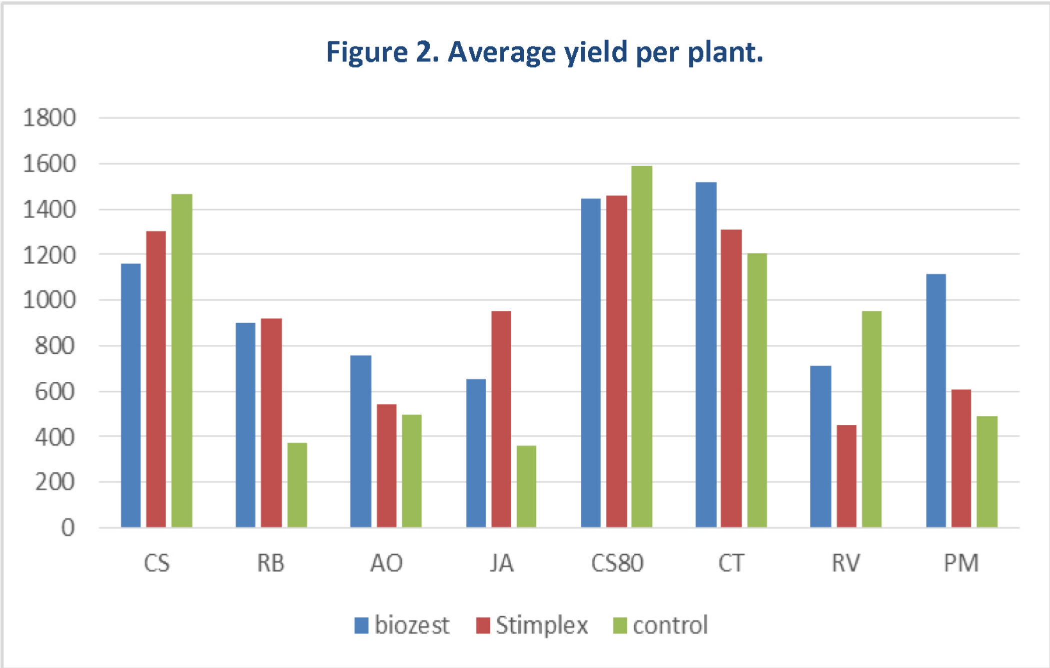


Table 1. Fruit weight of okra varieties treated with biostimulants and control.

Variety	Fruit (pod) Weight (gm)		
	Stimplex	**Biozest**	**Control**
Clemson Spineless	15.536	16.158	16.586
Annie Oakley II	14.027	14.874	15.206
Jambalaya	14.027	12.859	12.407
Red Burgundy	11.947	10.621	11.229
Clemson Spineless 80	17.327	17.414	16.083
Chant	16.421	19.502	18.159
Red Velvet	15.617	16.687	18.419
Perkins Mammoth	15.617	15.004	14.515

Conclusion

Most of the varieties of okra performed well under the treatment of biostimulants and positive effect of stimplex or biozest for crop enhancement in organic vegetable production system observed. Since these are the results from the one year trial, therefore, further research is needed to explain the complete benefits or the effects of the biostimulants and commercial production of crop.

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DESIGN AND FABRICATION OF A BANANA FIBRE MACHINE

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Abstract*:* The banana producing countries of the CARICOM region have been particularly challenged. The loss of preferential agreements in many major markets, exacerbated by the proliferation of pests and viruses that attack the banana plant, have led to significant losses in revenue over the past few years. With banana production being the key export in many of these countries, this has meant significant decreases in foreign exchange earnings and in general a blow to their national economies. Recognizing the significant investment in banana production infrastructure in these countries, efforts have been made to develop alternative markets based on the banana plant. It has been found that the fibre produced from the banana stalks has desirable material properties and can be used in paper production, craft creation and as an input for other bio-composite materials. Recent initiatives by some regional governments have begun to foster new markets for these fibres in the United States and Europe. However, exploitation of these markets would require significant regional capacity development, primarily in the form of increased fibre production levels. One solution is to design and construct a machine that meets the needs of the stakeholders of the region and the international market. This paper would discuss the design, fabrication and testing of a prototype banana fibre machine. The design process is unique as it uses both the standard engineering design process and an energy/impact loading analysis for the machine's critical components, permitting overall improvement in energy consumption. Testing was performed on the machine and it has been shown to produce fibres from the banana stalk more effectively, with comparable quality and at a higher production capacity per unit of energy utilized, as compared to existing designs used in other regions. This machine addresses some of the current challenges and in so doing, provides a critical component to the proposed alternative regional banana value chain.

Introduction

Traditionally, many islands of the Caribbean region have based their livelihoods on agriculture. In particular, the production of bananas for export has been a fundamental and predominant sector in the economies of many of the smaller island states. In recent times however, the removal of preferential tariffs, amendments to existing and formalizations of new trading blocks and agreements, and a number of other globalization induced dynamics, have negatively influenced the capacity of these island states to compete in international markets. Accordingly, this has led to lower market shares and in turn lower revenue streams for these countries. In keeping with this, many of these countries have sought new markets for their banana crops, as well as to develop value added products from the bananas with the intention of accessing new markets and the associated revenues available further down the value chain.

One such product has been the production of banana fibres. Natural fibres may be categorised as cellulosed (plant based), protein (animal derived) or mineral. Banana fibre can be categorized as a natural fibre by standard designations and requires less energy to manufacture as compared to synthetic fibres [1]. Natural fibres also have other key advantages over synthetic fibres [2] and have gained commercial popularity in recent years as a result of the textile manufacturing industry. Due to its high sheen and flexibility, fabric produced from banana fibre is quite thin and light weight, as compared to other natural plant based fibres, such as jute and pineapple leaf fibre. Its high strength and low strain properties have also made it possible for banana fibre to be used as an additive in fibre reinforced, polypropylene automobile floor panels.

The banana fibres produced by the Caribbean island states has the potential to be sold to the North American market, where manufactures can utilize them in craft production, paper and bio-composite materials. Currently however, a small amount of fibre production is done by hand or by small mechanical devices, and the production levels will be unable to meet the demand of these markets. Accordingly, there is a need for increased production levels to meet this demand. However, the availability of effective and suitable machinery can prove to be a challenge. For instance, India is the largest banana producer in the world, yet most of its banana fibre production and usage is directed to cottage industry applications. The main reason for its underproduction of more refined products, may be attributed to the limited scientific testing and data available regarding the proper mechanical extraction of banana fibre and its refinement [3].

One of the earliest machines for large scale production is credited to Frederick P. Gardner and it was designed to be used for pineapples, abaca and other similar fibrous crops. In the machine, both sides of the fibrous material were subjected to a shearing force by means of a continuously spinning bladed drum and a series of fixed blades [4]. Perhaps the most commonly available machine is the banana fibre decorticator or extractor, which utilizes a combination of compressions and continuous impacting to effectively beat the pulp material away from the fibrous sheaths [5]. Another notable existing design was developed by Krishi Vidyan Kendra and employs very similar operating principles to deliver a significant increase in fibre production over manual methods. This machine has the capacity to output up to 15 kg in an 8-10 hour period. Notwithstanding this, there are known efficiency issues with many of these machines, given the generic nature of the design. Additionally, many have low production capacities and are difficult to repair and maintain. More importantly, most machines have suffered from critical safety issues which have led to serious concerns and even more serious injuries in some cases.

In keeping with this, the current work seeks to develop a banana fibre machine to address the regional situation. The approach seeks to utilize key engineering design principles to develop a more effective machine, with a suitably larger capacity. Additionally, this design seeks to incorporate mechanisms that will allow for variability in the operational components, so as to optimize its use with different strains of banana plants. Emphasis will also be placed on the safety features of the design. The subsequent sections of this paper present the approach utilized in the design of the machine and key results obtained from the testing of a prototype. Lastly, an outline of the key findings obtained and the future work intended for the machine are presented.

Methodology

The methodology utilized in the design and development of the proposed banana fibre machine, follows six key stages. The first stage of the process involved conducting a review of existing literature, research documentation and patent documents. During this stage, the key issues of the work were identified and the core emphases refined. The second stage of the process entailed the development of design concepts. Data obtained from the first stage as well as from interviews conducted with key personnel, was used to identify the critical functional requirements of the machine, via a functional decomposition approach. This data was also used to obtain critical selection criteria, which was in turn used in a morphological approach to the development of various machine design concepts. The design concepts developed were evaluated via a pugh chart and the highest scoring design was selected for prototyping. The third stage of the process entailed the design of the selected concept. This is the subject of the subsequent section. Upon completion of the design, a bill of material quantities was developed. In the fourth stage, the selected design was fabricated. A full scale prototype was fabricated in the engineering workshop, of the Faculty of Engineering, University of the West Indies, St. Augustine Campus, utilizing standard machine shop practices. Stage five of the process involved testing of the manufactured prototype. The two key aims of the testing process were to optimize the machine parameters for a given strain of banana pseudostems and to identify key aspects of the design that required further improvement. An outline of the testing process is given in Section 3.3. The final stage of the process is iterative and involves the continuous improvement of the design via testing and re-engineering. Currently, this stage is ongoing.

Description of design

The prototype features a beater roll similar to some existing machines, but differs significantly in the manner in which pseudostem sheaths are fed to the system, as well as how the fibres are removed post processing. Pseudostem sheaths are sent in at the top of a bed plate, leading to a pair of horizontal squeezing rolls. The clearance between these rolls is adjustable, depending on the size of the feed stock. At the very end of the bed plate, a beating roll is restricted to spin on a horizontal axis, where it beats the pulpy material out of the sheaths, separating it to obtain the long banana fibres, while concurrently drawing the feed stock into the machine. The bed plate ends in a downward acute angle, to allow the banana fibres to fall freely downward, between two closely spaced rolls. A fixed rubberised plate is positioned to the closest allowable position to the spinning blades to prevent waste material from going down with the fibres into the rolls. The speed of these rolls will serve two main purposes. Firstly, since it will spin at a slightly higher speed than the feed rolls, it will maintain a degree of tautness in the fibres during processing. This also aids in directing them towards the conveyor system which finally allows the user to remove the processed fibres safely by hand. The design is powered by two independent, variable speed motors and power is also transmitted by an intermediate belt drive between the first motor and the drum. Figure 1 shows a drawing of the prototype.

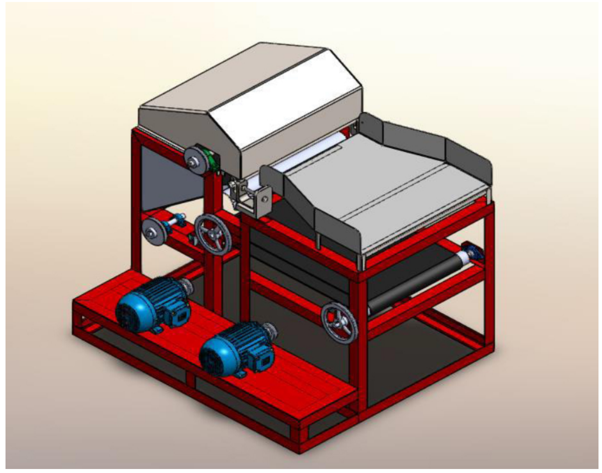

Figure 1: Design drawing of the prototype

Testing Procedure

Testing of the device was conducted using banana pseudostems obtained from the Faculty of Food and Agriculture's field station, at the University of the West Indies, St. Augustine Campus. The tests were conducted using one strain of banana species. The primary aim of the tests were to determine the optimal parameters for fibre yield of the given banana plant species. The main steps of the testing process were as follows:

1. The feed system was adjusted to an initial blade clearance of 0.61mm, and the nuts of the carriage assembly secured.
2. The motor supplying power to the drum was started and its speed slowly increased to approximately 500 rpm.
3. Two pseudostem sheaths were weighed and fed into the drum separately, for a period of 8s each. For safety reasons, only a portion of the sheaths were processed, while the remaining piece served as a handle. To account for the unprocessed material, the remaining stumps were cut free from the fibres and the difference in mass measured.
4. Steps 1-4 were repeated at 550 rpm, 600 rpm and 640 rpm respectively.
5. The motor was then switched off and the clearance adjusted. The entire procedure was repeated for clearances of 0.457mm and 0.12 mm.

Design Approach and Analyses

The design of the prototype was perhaps the most critical component of the work. The low efficiencies in some existing machines can be attributed to the ineffective design process. More specifically, though the fibres are flexible they can be damaged during the extraction process. Additionally, the force or energy required to separate the fibres may vary depending on the fibre composition and size [6]. Key to the extraction process is the use of a method that delivers sufficient force to separate the pulp from the fibres in a manner that allows for easy removal, while not damaging the fibres themselves. Machines that cater for several varieties of crops generally do not have enough specificity in the design of the separation process and can be either too harsh destroying some of the fibres in the process or inadequate leading to insufficient fibre removal. In addition, machines that are geared to one species of banana plant also run the risk of decreased efficacy when using other species. Accordingly, the current prototype seeks to optimize the separation process by varying the machine speed and clearance distances, allowing for variations in the separation force applied.

Accordingly, the most crucial aspect of the design process was the determination of the energy requirement for the separation process. The first stage in this process involved determining the failure stress of the banana pseudostems. Pseudostem samples were acquired and underwent compression testing using a Tinius Olsen compression testing machine. During the tests, the samples were compressed until the pulp began to separate from the fibrous material. The values of the force applied at that point were recorded for several samples, in addition to the magnitudes of the compression of the material. This data was then used to calculate the value of the work done or strain energy via the expression: $U = \int_0^x F dx$, where x represents the displacement through the material, F represents the applied force and U the strain energy. Subsequently, the strain energy absorbed per unit volume was calculated. An average value of the strain energy per unit volume was further calculated from several samples, and represents the amount of energy that must be applied to a unit volume of pseudostem material to achieve successful separation. Considering the proposed dimensions of the blade that would strike the pseudostems, the angular velocity required to achieve a sufficient impact force and deliver the required strain energy was then calculated. Subsequently, the torque required for a given angular velocity was then calculated, and ultimately, the power requirement of the machine.

The other components of the prototype were designed based on the strain energy and power requirement values previously calculated. This included the design of the belt drive system to transfer power from the motor to the requisite power shafts; the main emphasis here was the determination of belt tension and speed. The other key aspect of the design process involved the determination of component dimensions and material types, for all of the load bearing components of the design. This included the blades, drum plate, shafts and the frame. This was primarily done utilizing the finite element analysis capabilities of the software package SolidWorks but was also corroborated by hand calculations. Figure 2 depicts some of the analysis results provided by the software.

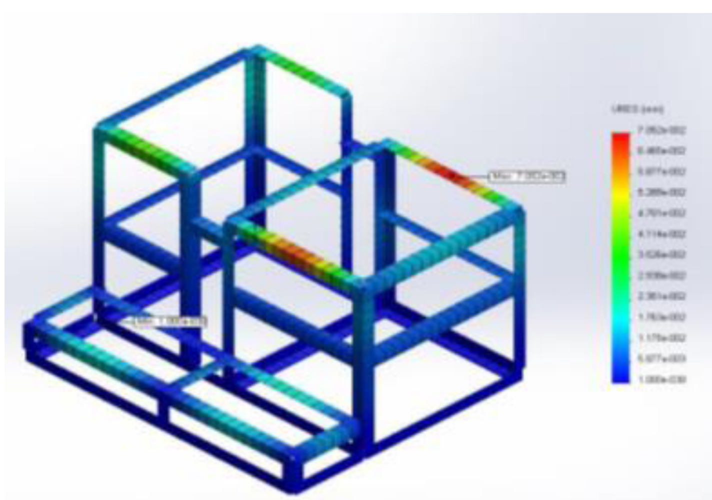

Figure 2: Finite element modelling and analysis of the prototype frame via SolidWorks

Results and Discussion

A summary of the results obtained from testing the fabricated prototype, are presented in Table 1. Additionally, Figure 3 shows a photo of the prototype and some separated fibres.

Clearance used (mm)	Stem before processing (kg)	Stem after processing (kg)	Stump (kg)	Shredded material (kg)	% fibre yield	drum rpm	rate of shredding (kg/hr)	Average rate (kg/hr)
0.61	0.389	0.221	0.178	0.043	20.38	554	0.32	
	0.264	0.125	0.09	0.035	20.11	554	0.26	0.29
	0.493	0.178	0.135	0.043	12.01	605	0.32	
	0.443	0.177	0.121	0.056	17.39	605	0.42	0.37
	0.309	0.125	0.104	0.021	10.24	645	0.16	
	0.204	0.091	0.065	0.026	18.71	645	0.2	0.18
0.457	0.361	0.265	0.238	0.027	21.95	554	0.2	
	0.357	0.183	0.156	0.027	13.43	554	0.2	0.20
	0.406	0.258	0.223	0.035	19.13	602	0.26	
	0.296	0.179	0.147	0.032	21.48	602	0.24	0.25
	0.149	0.082	0.061	0.021	23.86	641	0.16	
	0.252	0.135	0.106	0.029	19.86	641	0.22	0.19
0.12	0.273	0.171	0.128	0.043	29.66	557	0.32	
	0.2	0.103	0.069	0.034	25.95	550	0.26	0.29
	0.219	0.147	0.125	0.022	23.4	600	0.17	
	0.164	0.111	0.096	0.015	22.06	600	0.11	0.14
	0.335	0.12	0.097	0.023	9.66	641	0.17	
	0.259	0.123	0.098	0.025	15.53	640	0.19	0.18

Figure 3: Prototype with tested samples resting on the feed tray

Table 1 shows results for drum speeds of 550, 600 and 650 rpm. Tests were also carried out at speeds of 500 rpm and lower. However, it was found that at those speeds, there were incomplete or low levels of fibre separation. This can be attributed to the inadequate transference of energy to the pseudostem samples at these speeds; at these speeds the blades were unable to transfer the required levels of strain energy. Accordingly, this places a lower limit on the speeds that can be used for effective operation.

The results show the highest rate of fibre production during the tests to be 0.37 kg/hr. This was obtained at a drum speed of 600 rpm and a clearance of 0.61 mm. This result suggests that this combination was the optimum arrangement for the pseudostem samples tested. Of particular interest were the trends observed in the results. Firstly, it can be seen that for the 0.61 mm and 0.457 mm clearance widths used, the highest production rates occurred at 600 rpm and decreased at higher speeds. A second trend of interest was that generally production rate decreased with decreasing clearance width used; the notable exception to this would be the 0.12mm width, 550 rpm combination. Collectively, the results indicate that there exists an optimal value of energy that must be imparted to the pseudostems to ensure the most effective fibre separation process. As this energy is primarily imparted via impact, a variation in the distance between the blades and the pseudostems (changes in clearance widths) must be balanced by changes in the blade speed. At the same time, these parameters represent the machine configuration for which its energy is best utilized and least wasted. Accordingly, an effective banana fibre extracting machine must be able to vary its parameters to achieve this.

In general, the tests demonstrated that the machine was capable of achieving its primary function effectively. During testing, one key problem observed concerned the waste removal conveyor system, which suffered from a shifting belt drive. With the exception of this, the machine functioned as designed. For the purposes of the tests, small samples of pseudostems were used, leading to low fibre production rates. This limited use of material was to facilitate observation and analysis of the machine's basic components and overall performance. However, the machine was capable of processing several pseudostems at once. In keeping with this, current work includes the redesign of the machine's waste removal system to facilitate better functionality. In addition, further testing is to be done using large feed rates and longer operational times, to determine the implications of long term operation. This work is currently ongoing.

Conclusion

Changing market conditions have made it necessary for the banana producing small island developing states of the Caribbean region to explore the production of value added banana products. Some of the products being considered require banana fibres as the feedstock. However, these are generally made by hand in quantities that are unable to support the market's demand. The current work seeks to design a banana fibre extraction machine that has a production capacity suitable for the regional banana fibre producers.

A prototype was designed using standard engineering principles. Critical to the design process was the utilization of a strain energy approach in the determination of the energy requirement for successful fibre removal. Additionally, the design sought to incorporate the capacity to vary the machine's parameters, so as to optimize the fibre separation process for varying banana plant strains. The prototype design was fabricated and tested at the University of the West Indies' St. Augustine Campus. The tests confirmed that the design was successfully able to meet its primary objectives. Further, the variation of the prototype's operational speed and clearance distance verified that there is an optimal value of force or energy that must be applied to the pseudostems for optimal fibre yield. This variation in the prototype's parameters allows it to be further calibrated for optimal fibre production for various banana plant strains. Despite the machine's general success, problems with one of its subsystems were identified. Additionally, the testing process did not assess the prototype's capacity to process large capacities of pseudostems, or the impact of long term machine operation. These concerns, as well as the examination of the machine's yield for various strains of banana plant, are currently the focus of ongoing work by the research and design team.

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VACUUM FREEZE DRIED PUMPKIN POWDER

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Abstract*:* Pumpkin, a rich source of anti-oxidants, vitamins and minerals, is an important traditional vegetable crop in Trinidad and Tobago and other Caribbean countries. It is an important part of the local diet where it is mainly produced by small farmers. Three days after peeling, pumpkins spoil when stored at 4^{o}C. One method of preserving the benefits of this versatile vegetable is to produce a powder. Pumpkin powder can be used in many food items such as beverages, soups, sauces, flour products and snacks. Five pumpkin varieties, which included Future NP 999, Bodles Globe, CES-Starz, Crapaud Back and Iron Cap, were vacuum freeze dried at -43^{o}C using a Armfield (FT33) Vacuum Freeze Drier (Ringwood England UK). Results showed that colour and odour of pumpkin were maintained after being vacuum freeze drying. The powders of the Bodles Globe followed by other local varieties were rated the highest for their sensory characteristics, fine powders, intense orange colour and moderate odour. The Future NP 999 produced the lightest powders of lowest density. Comparatively, the values for the fresh qualities of the oven dried samples tested were notably lower than that of similar vacuum freeze dried samples. Moreover, their colours turned to greyish brown. There is need for further research on microbial analyses, optimum storage condition and packaging materials.

Keywords: Pumpkin, vacuum freeze dried

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PRELIMINARY INVESTIGATIONS INTO THE PRODUCTION OF FREEZE-DRIED PUMPKIN POWDERS

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Abstract: The production of freeze dried pumpkin powders was investigated using five cultivars of pumpkins. Pumpkin purees were frozen then dried in a vacuum freeze drier. The resulting dried 'cakes' were pulverized to produce powders, which were compared with purees dried in an oven at 65°C. For all cultivars, freeze dried powders were superior in colour compared with air dried samples. Colour attributes and selected physico-chemical results for the different cultivars are presented.

1.0 Introduction and Objectives

Dehydrated fruit and vegetable powders can be used in many products, including instant soups, snacks and in bakery and beverage applications. The production of a dried pumpkin powder or flour presents an opportunity to add value to this carotenoid-rich fruit, which is also high in carbohydrate and minerals. Hot air drying of pumpkin slices often leads to severe discoloration and hardening of slices to a point where reconstitution or pulverizing to a powdered form are difficult. Several researchers have therefore investigated the impact of several types of drying pre-treatments (such as blanching, osmotic treatments, sulphiting and enzymatic treatments) to alleviate deleterious changes which may occur during hot air drying (Arevalo-Pinedo and Murr, 2007; Falade and Shogaolu, 2010; Konopacka et al. 2010; Lee and Lim, 2011; Olurin et al. 2012). Some authors have investigated alternative drying methods such as spray drying, vacuum and vacuum-microwave as a means to create higher quality dried pumpkin pieces and powders (Nawirska et al., 2009; Shavakhi et al., 2011). In work done regionally, Harrynanan and Sankat (2013) investigated the foam-mat drying of a locally available pumpkin hybrid as a means to produce a dried porous foam which could be easily converted to a powdered form. Harrynanan and Sankat (2013) reported that pumpkin puree foamed using glycerol monostearate together with methyl cellulose stabilizer could be dried at 60°C to produce porous 'mats', which could be easily blended into powders. They reported very little changes in colour between the purees and dried mats, adding that the foaming procedure also enhanced drying rate.

This work seeks to advance the knowledge on the production of dried pumpkin powders from regional and local cultivars of pumpkins and will investigate the feasibility of using vacuum-freeze drying as a method to produce high quality pumpkin powders. The drying of the material takes place while the material is frozen and consists of two stages; the sublimation stage during which product shape is maintained, and the secondary drying stage which removes unfrozen water. The potential advantage of this method of drying would be high quality powders free from any added ingredients and drying agents (Que et al., 2008; Dirim and Caliskan, 2012). This present project forms part of a larger body of work being conducted at the Food Science and Technology Unit at the Department of Chemical Engineering, investigating the freeze drying of fruits and vegetables to produce ready-to-eat snacks and dried powders. The objectives of this study were to:

- Establish the feasibility and suitability of freeze drying as a method of producing pumpkin powders from 5 pumpkin cultivars.
- Compare the quality of freeze-dried powders to those obtained using conventional hot air oven-drying.

2.0 Materials and Methods

2.1 Raw material handling and preparation

Five (5) pumpkin *(Cucurbita maxima* Duch.) cultivars were evaluated: Future NP-999 (imported Chinese variety), Bodles Globe (Jamaican variety), CES STARZ (a new variety developed by the Ministry of Food Production, Trinidad, larger fruit), Crapaud Back (Trinidad) and an unidentified local cultivar with a smooth skin, called Smooth Skin. Cultivars Future NP-999, Bodles Globe and CES STARZ were obtained through a specially funded Project*. These pumpkins were grown at the University Field Station, Valsayn, Trinidad, over the period 2013 to 2014. Crapaud Back and Smooth Skin pumpkins were purchased at the local market. Pumpkins were stored in a refrigerated walk-in chiller (4°C) located at the Food Processing Laboratory at Department of Chemical Engineering until it was ready for use. The fresh fruit characteristics are given in Table 1. Pumpkins were cut, peeled and seeds removed before being sliced using a Hobart Slicer (Model 1612, Ohio USA). The pumpkin slices were pureed in a Model CB16, Waring Commercial blender (Connecticut, USA). For freeze drying, 30g samples of pumpkin puree were plated into plastic Petri dishes which were then placed in resealable freezer bags and frozen for a minimum of 48 h at -18°C in a chest-type freezer. For samples to be air dried, 30g each of pureed pumpkin was placed into glass petri dishes and dried immediately.

2.2 Drying methods

Freeze drying of frozen samples was carried out on duplicate samples in a laboratory-scale vacuum freeze drying unit (Benhay SB-4, UK) under vacuum (13.3 Pa) at a condenser temperature of -44°C and heating temperature of 30°C (Dirim and Caliskan, 2012). Petri dishes containing samples were carefully placed inside the freeze dryer and drying was continued until constant weight was attained. This was determined from preliminary experiments to be 64h. To compare the quality of air-dried purees, separate pumpkin puree samples were dried in a UNITEMP Air Drying Cabinet (LTE Scientific Ltd., Greenfield, Oldham) for 9h at 65°C. The dried 'cakes' were pulverised in a laboratory blender to obtain powders which were stored in resealable plastic bags placed into sealed glass jars airtight glass jars until analysis.

2.3 Analytical methods

Before pureeing, the weight and dimensions of whole pumpkins and selected physical measurements of cut pumpkins were recorded. Pumpkin weight was measured using a platform scale. Sample weights (0.01±0.005g) were also measured using an Explorer Pro Balance, Model EP2102C (Ohaus Corporation, NJ, USA). Physio-chemical analyses were done in duplicate on the fresh pieces and pumpkin powders. Moisture content of the fresh and dried samples was measured using a Halogen Moisture Analyzer HB43-S (Mettler Toledo-AG, Zurich, Switzerland) set at 115°C. Water activity (a_w) was measured using an Aqua Lab CX-2 water activity meter (Decagon Devices Inco., Pullman, WA, USA). Flesh firmness was assessed using a Wagner penetrometer (Wagner Instruments, CT, USA) and flesh colour (L^*, a^*, b^*) was measured using a

Minolta Chroma Meter (Model CR-410, Minolta Corporation, NJ, USA). The maximum for "L^*" value is 100 (white) and the minimum is zero (black). Positive "a" value is red, negative "a" is green, while positive "b^*" value is yellow and negative "b^*" is blue. Hue angle (°), Chroma and Total colour difference (□E) between fresh and dried leaves were calculated as given in Equations 1 through 3.

$$Hue = Arc \tan\left(\frac{b^*}{a^*}\right) \quad (1)$$

$$Chroma = \sqrt{(a^{*2} + b^{*2})} \quad (2)$$

$$\Delta E = \sqrt{(L^*{}_0 - L^*)^2 + (a^*{}_0 - a^*)^2 + (b^*{}_0 - b^*)^2} \quad (3)$$

Total soluble solids, pH and titratable acidity of samples were determined by first blending an appropriate quantity of fresh pumpkin or powder in distilled water followed by filtering using Whatman filter paper (No. 2) to obtain a clear supernatant. Based on preliminary testing of procedure, a ratio of 1:5 (sample: water) was used for the fresh pumpkin samples (Rahman et al., 2013) and a 1:20 ratio was used for the powdered samples. Sample pH and total soluble solids (TSS) were determined using a Hanna pH/ORP Meter (Model HI 991002, Woonsocket RI, USA) and Abbe Mark III Refractometer (Reichert Analytical Instruments, New York, USA), respectively. Density (g/ml), wettability (s) and solubility (s) of freeze dried and air-dried powders were measured according to Dirim and Caliskan (2012). Percentage yield of dried powder was calculated based on the fresh weight as given in Equation (4):

$$\text{Yield (\%)} = \frac{\text{Weight of powder (g)}}{\text{Fresh Weight (g)}} \quad (4)$$

3.0 Results and Discussion

As given in Table 2, all oven dried cakes were discoloured and changed to a brown/grey colour with slight pumpkin odour. During air drying, the samples showed severe shrinkage, became very hard and developed cracks. The freeze dried cakes were found to maintain the colour of the fresh samples, with the cakes of Bodles Globe, Crapaud Back and Smooth Skin pumpkins being very attractive in colour. Freeze dried 'cakes' from all varieties except the Future NP-999 cultivar could be described as "spongy" in texture and were easily pulverized to fine powders using a blender. The cakes of Future NP-999 were somewhat sticky and produced grainy powders. Freeze dried cakes of Bodles Globe, Crapaud Back and Smooth Skin purees were deep orange in colour with the pumpkin odour in the Crapaud Back and Smooth Skin being described as "Strong". Air dried samples darkened in colour and maintained only a slight pumpkin odour after drying. Dirim and Caliskan (2012) also noted the importance of visual appeal of powders, which affect marketability. Ideally, the colour of a dried product should remain unchanged after processing. Que et al. (2008) also reported severe browning of pumpkin slices during air drying at 70°C.

Selected characteristics of the fresh, freeze dried and air dried powders are given in Table 3. The average initial moisture content of the pumpkins was found to range from approximately 84% (wb) for Future NP-999 to 94% for Crapaud Back pumpkins. Initial water activity values were not significantly different in four varieties, but was higher in Smooth-Skin pumpkins, averaging 0.998. The moisture content of pumpkin samples of fresh and dried samples is given in Figure 2. Moisture content was reduced from an initial average of 89.3% wb to an average of

5.5% in freeze dried samples versus and average of 3.0% in oven-dried samples. Moisture content was significantly ($p \leq 0.05$) affected by variety, drying method and a variety-method interaction. Initial water activity averaged 0.981. The water activity values of dried samples were found to be significantly affected by variety ($p \leq 0.05$) but not by drying method. The water activity values for freeze-dried samples averaged 0.314, and 0.330 for air-dried samples. Dirim and Caliskan (2012) reported a decrease in moisture content of *Cucurbita moschata* purees from 92.3% to 3.9% after freeze drying. Water activity decreased from 0.988 to 0.197. Water activity is a measure of moisture that is available to microorganisms and designing a product with a water activity below 0.60 is considered an effective control measure (Montville and Matthews, 2005).

Colour L^*, a^*, b^* values were significantly affected by variety and drying method and there was a variety-treatment interaction effect for L^* and b^*values ($p \leq 0.001$). Hue angle (°) was affected by variety and drying method and the Chroma and □E values were affected by variety and drying method ($p \leq 0.001$). Colour difference values between fresh and dried samples support the overall results that the freeze dried powders were closer in colour value to the fresh samples when compared with oven dried powders (Table 3). On average, □*E* values for freeze dried samples averaged 12.1 while values for oven dried samples averaged 30.1. The initial pH of varieties ranged from 4.6 to 6.4, but the differences between the pumpkin varieties were not statistically significant. As also found by Que et al. (2008), air dried pumpkin powders were much darker than fresh and freeze-dried samples, and therefore had lower L^* values together with higher b^* values. Harrynanan and Sankat (2013) reported that the foaming process prior to oven drying of pumpkin purees resulted in a 30% increase in lightness. They reported a slight increase in Hue values (°) of foam-mat dried pumpkin powders during a 60-day storage period.

The pH of dried samples was significantly affected by variety and drying method and interaction ($p \leq 0.05$). Of the fresh samples, the total soluble solids content of fresh samples was highest in Smooth-skin pumpkins (5.25 %) and lowest in CES STARZ fruit (1.55 %). The total soluble solids content of dried samples was significantly affected by variety and drying method and interaction ($p \leq 0.05$). As expected, the soluble solids content of dried powders was very high as calculated on a fresh weight basis, with the values being higher in freeze dried samples.

Table 3 gives selected properties of powders obtained by freeze and air drying. The yield of pumpkin powder obtained for the freeze drying and air drying processes was found to vary with both variety and drying treatment ($p \leq 0.05$), with yields being consistently higher in freeze dried samples (Figure 1). Of the freeze dried samples, slightly higher yields of 8.6, 9.6 and 9.4% were obtained for the Future NP 999, Bodles Globe and CES STARZ varieties compared with 7.9 and 8.1% yield for Crapaud Back and Smooth Skin purees. Due to the very sweet odour emanating from the air dried samples during drying, it was suspected that caramelization of sugars could have been occurring during air drying. Wettability values of the dried powders ranged from 687 to 702 s. Values differed with variety ($p \leq 0.05$) but not by drying method. Solubility of powders ranged from 12 to 13.5 s and solubility was not affected by variety or drying method. Bulk, tapped and shaken density values given in Table 2 were affected by variety and drying treatment effect ($p \leq 0.001$). Bulk density values for freeze dried powders ranged from 0.18 to 0.26 g/ml and 0.22 to 0.39 g/ml for oven dried powders. Que et al. (2008) found that air dried pumpkin powders had higher solubility values when compared with freeze dried powders. As also found in this study, they also reported that air dried samples had higher bulk density values. Dirim and Caliskan (2012) noted that these properties are indicative of the reconstitutive capacity of powders. In that study, the bulk density of freeze dried pumpkin powder averaged 0.113 g/ml while solubility and wettability values averaged 710 s and 16 s, respectively.

4.0 Conclusions

While both freeze drying and air drying methods effectively reduced MC and lowered a_w, of pumpkin purees, the colour attributes were found to be superior in freeze dried samples compared with air-dried samples. Freeze dried 'cakes' from all varieties could be described as "Spongy" in texture and were easily pulverized using a blender. Air dried cakes suffered from shrinkage and cracking during drying. Freeze drying of pumpkin purees gave fine powders with noticeably improved colour and less granular texture than powders obtained using hot air drying. Appealing freeze-dried powders were obtained from the Bodles Globe, Crapaud Back and Smooth Skin pumpkins. Future NP-999 fruits produced the least favourable powders based on colour, odour and texture.

Acknowledgement

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IDENTIFICATION OF *PHYTOPHTHORA* AND EVALUATION OF ITS TOLERANCE IN CITRUS ROOTSTOCKS IN PUERTO RICO

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Abstract: For decades researchers and citrus growers have reported a dramatic decline in the production of citrus in Puerto Rico. It has been speculated that the mortality of the trees is related to the presence of the fungus *Phytophthora*. Symptoms observed include slow decline, leaf chlorosis, die back, canker in the base of the stem, and gummosis. A survey was carried out in citrus commercial fields and experimental plantings with different rootstocks at UPR-AES substations. ELISA tests were performed to select samples positive to *Phytophthora*. Isolations were carried out, from both root and stem bases. The samples were taken from the area between healthy and diseased tissue, surface-sterilized and plated on the *Phytophthora* modified selective medium PARPH. Pure cultures were sent to the University of Maryland for molecular identification; from those, 26 isolates were identified as *P. nicotianae* (syn. *P. parasitica*) and 46 as *P. citricola*. Studies were conducted to compare existing and potential citrus rootstocks with respect to resistance to *P. nicotianae* and *P. citricola*. Stem pathogenicity tests were performed with Rough Lemon, Swingle Citrumelo and HRS-812. Seedlings were inoculated with 7-day-old *P. nicotianae* and *P. citricola* pure cultures. The control was inoculated with V-8 agar. The extent of lesion development on the stem was visually rated on a pre-transformed scale of 0 to 5, after 88 days of inoculation. The lesion was measured, the average was determined and the presence of gum exudation was recorded. Rough Lemon showed greater susceptibility to both species of *Phytophthora* when compared to Swingle and HRS-812. Swingle and HRS-812 are described in the literature as having moderate to high levels of resistance, perhaps because of inheritance from Poncirus trifoliate, a major germplasm source resistant to *Phytophthora*. Control plants did not show symptoms.

Keywords: *Phytophthora*, ELISA, rootstocks, tolerance.

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HIGH CAROTENE VARIETIES OF SWEET POTATO FOR PUERTO RICO

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Abstract: A major limitation to reach Puerto Rico's full production potential of sweet potato is that the currently available varieties conform only partially to the needs of the farmer and the market. Orange-fleshed varieties recommended for Puerto Rico are limited to two genotypes selected in the late 1950s and early 1960s. Conversely, recently selected tropical-type varieties have high yield stability and reasonable commercial production but fall short regarding yellowness of the flesh for the fresh market. Orange-fleshed sweet potato accessions were imported from the Sweet Potato Clonal Repository of the USDA. Evaluations under field conditions showed that PI 208796 and PI208806, identified as clones 469-PR and 485-PR respectively, were the most promising in terms of commercial yield. Elite selection of tropical-type clones of sweet potato were evaluated for carotene content. Flesh of tropical-type clones tends to be light yellow in color. B-carotene content varied from 0.06 to 1.03 ug/g, whereas total carotenoids content varied from 0.51 to 2.10 ug/g.

Keywords: sweet potato, carotene.

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GALL FORMATION ON THE ENDANGERED CACTUS, *LEPTOCEREUS QUADRICOSTATUS* CAUSED BY THE INVASIVE MEALYBUG, *HYPOGEOCOCCUS PUNGENS* (HEMIPTERA: PSEUDOCOCCIDAE)

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Abstract: The introduction of Harrisia cactus mealybug (HCM), *Hypogeococcus pungens*, in Puerto Rico causes concern due to its damaging effects to the structure of cacti communities, eliminating species, and severely compromising plant growth and reproduction of susceptible native species. HCM is a polyphagous soft scaly insect considered an aggressive pest outside of its native range of South America. In Puerto Rico, three native species of cacti have been observed to be heavily infested with this invasive HCM, the natives *Pilosocereus royenii*, *Melocactus intortus*, and the endangered *Leptocereus quadricostatus*. Recent studies have shown that HCM affects the growth and survival of *P. royenii*, but limited information is available about the other affected species. To understand more about the threat of HCM, greenhouse experiments were designed to evaluate the pest colonization and to describe the development of galls on the columnar cactus *L. quadricostatus*. The experimental design consisted of two groups of *L. quadricostatus*, infested and non-infested, the infested treatment received twenty crawlers and six females of HCM. The first signs of successful infestation were observed at 27 days after the initial pest transfer, while the first signs of gall formation were observed at 97 days. The initial infestation process was best explained by an exponential growth model (R2=0.93, F=125.4, df=1,9, p-value < 0.05). This stage can be identified by the formation of a powdery wax-like white spot on the areole of the cactus. Also four types of gall structure were observed. To our knowledge this is the first time that the full infestation process and gall development, by HCM has been replicated under controlled conditions. These results provide a better understanding of the interaction between HCM and the endangered host plant, and will help to develop more effective management strategies.

Keywords: Endangered Cactus Species, *Hypogeococcus pungens*, Invasive Species, Mealybug.

Introduction

The introduction of species into new localities and their ecological consequences on native species and local communities are of main concern to conservation biology. Harrisia cactus mealybug (HCM), *Hypogeococcus pungens,* is a polyphagous gall-inducing small scaly insect considered an invasive aggressive pest outside of its possible native range of South America. *Hypogeococcus pungens,* was first detected in San Juan, Puerto Rico fifteen years ago on an ornamental plant, *Portulaca oleracea* (Family: Portulacacea) and in plant material from Guánica in 2005 (Segarra-Cardona et al., 2010). HCM is native to some parts of South America that include Argentina (Williams & Granara de Willink. 1992; Claps & De Haro 2001), Chile, Brazil, Peru and Paraguay (Zimmerman et al. 2010). This species has been introduced and used before as biological control agent for populations of introduced cacti species in Australia (Tomley & McFadyen 1985) and South Africa (Moran & Zimmermann 1991; Paterson et al., 2011).

The introduction of HCM, *H. pungens*, in Puerto Rico causes concern due to its permanent negative effects to the structure of cacti communities, eliminating susceptible native cacti species (Segarra-Cardona et al. 2010). In Puerto Rico, three important species of cacti have been observed heavily infested with the invasive HCM, the natives *Pilosocereus royenii*, (Fig. 1A), *Melocactus intortus* (Fig. 1B), and the endangered (Quevedo et al. 1990, Gann & Taylor 2013) *Leptocereus quadricostatus* (Fig. 1C). HCM is known to induce morphological grown abnormalities, known as galls, in its host cacti species in Puerto Rico. Recent studies have shown that HCM affects the growth and survival of *P. royenii*, but little is known about the other affected species (Rodrigues et al., 2012). *Leptocereus quadricostatus* ((Bello) Britton & Rose) is a columnar cactus species (Cactaceae) found in the dry forest of the southern coast of Puerto Rico and Anegada, at the northernmost part of the British Virgin Islands (BVI) (Monsegur 2009). There is limited information on the biology of this species. Due to its limited distribution and small population size this cactus is currently listed as endangered by the International Union for Conservation of Nature (IUCN; Gann & Taylor 2013). The two main objectives of this study were: 1) Evaluate the infestation and the population growth of Harrisia cactus mealybug on *Leptocereus quadricostatus*; and 2) Characterize symptoms and gall development induced by Harrisia cactus mealybug infestation.

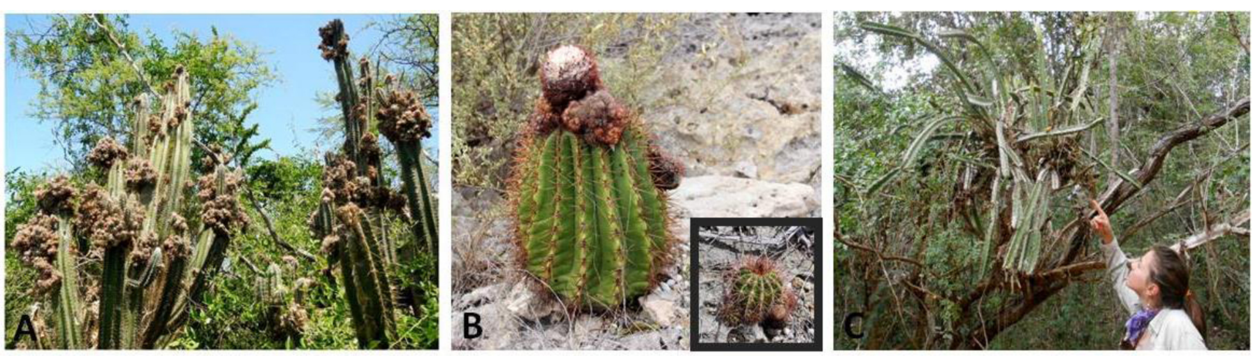

Figure 1. Native cacti species *Pilosocereus royenii*, *Melocactus intortus* and *Leptocereus quadricostatus* infested with *Hypogeococcus pungens* in Guánica, PR.

Material and Methods

A total of ten potted plants (10L pots) of *Leptocereus quadricostatus* were infested with six (6) adult females and twenty (20) crawlers of *Hypogeococcus pungens* (HCM) from colonies originally collected at USFW Reserve in Cabo Rojo, PR. Equal numbers of plants were maintained without receiving the infestation of the pest, serving as controls for the experiment. All plants were maintained under the same environmental conditions in a greenhouse at the Center for Excellence in Quarantine & Invasive Species (CEQIS) at the Botanical Garden of the University of Puerto Rico. All plants received standardized fertilization and irrigation. The temperature in the green house was monitored using a Hobo Pro v2 temp /RH data logger (Onset Corp., MA, USA). The plants were monitored for development of symptoms and population dynamics of the HCM. Observation about first signs of infestation, establishment of colonies and symptoms were recorded. To access population growth at the stage of establishment, the number of all colonies per plant were recorded for a period of 3.5 months. In that period the number of galls were also recorded. The development of galls was closely followed, documenting them with pictures and size measurements. A regression analysis was performed in R (R Core Team. 2015) to determine the adjusted model that most closely fit the colony population development.

Result and Discussion

Development of HCM on *Leptocereus quadricostatus*

The experiment, carried out under greenhouse conditions, was able to successfully reproduce the infestation of HCM on *L. quadricostatus*. The temperature in the greenhouse averaged 31.1 ± 4.8°C, with maximum and minimum temperatures of 45.2°C and 23.9 °C. HCM colonies were established and observed on the host cactus areoles (at the base of the spines) at 27 days from an initial infestation event. We observed that each initial colony had an average of 0.67 ± 0.6 (n=6) reproductive females per colony with a maximum of 3 reproductive females per colony. An exponential growth model best explains the initial colonization stage by HCM on *L. quadricostatus*. (R^2=0.93, F=125.4, df=1,9, p-value < 0.05; Fig. 2).

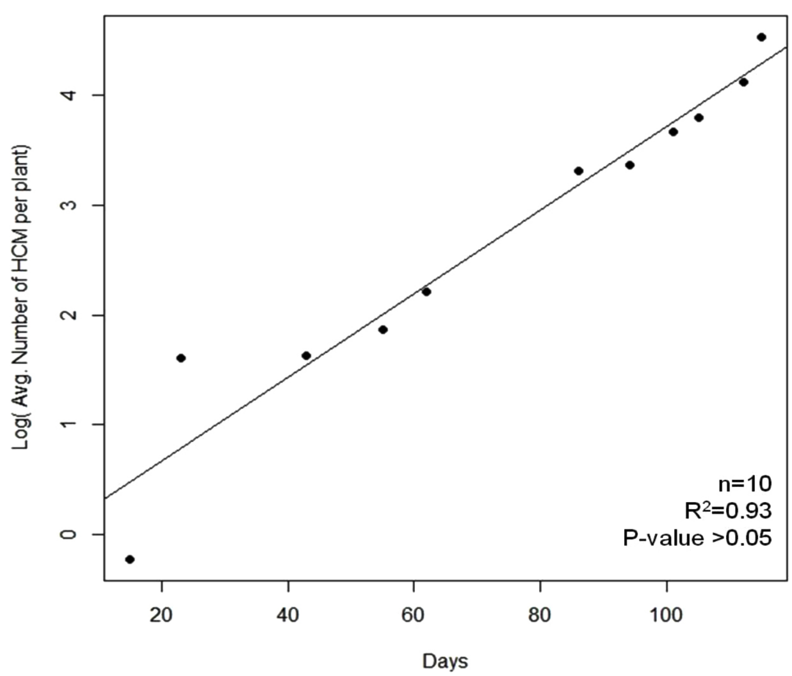

Figure 2. Initial colonization stage by HCM on *Leptocereus quadricostatus*. The colonization process is best explained by an exponential growth model. (R^2=0.93, F=125.4, df=1,9, p-value < 0.05).

In this study in a controlled environment, the only limitation for HCM to continue growth was the progressive reduction of availability of proper sites for establishment of the colonies (areole availability). HCM colonization takes place in the cactus areoles, if there aren't new areoles available there cannot be new establishment or colony formation. This same pattern has been observed in naturally occurring infested plants of *L. quadricostatus*. Despite the high HCM colony densities observed in this study, *L. quadricostatus* produced flowers in more than one individual in both the infested and non-infested plants.

Symptoms caused by HCM infestation on *Leptocereus quadricostatus*

Infested individuals of *L. quadricostatus* developed two main initial conspicuous visual symptoms. First, were observed the formation of a powdery wax-like white spot on the areole of the cactus resulting from the mealybug secretions (Fig. 3A). This symptom represents the visual cue of a new colony on an infested plant. In addition, in some cases this white spot is not evident and instead we observed a curling (bending) of the cactus branch (this also occurred in areoles with white spot). This curling pattern was usually observed at one of the sides of the secondary and tertiary branches or close to the apex of the cactus (Fig. 3B).This type of branch deformity was never observed in non-infested cacti plants.

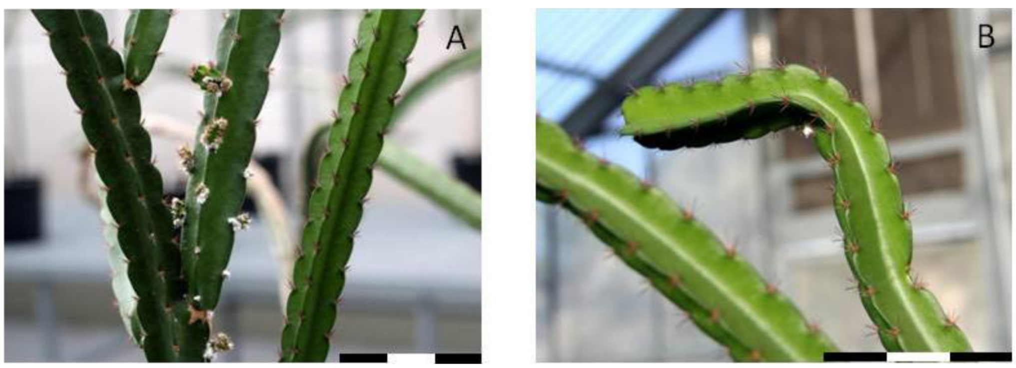

Figure 3. Initial infestation stage symptom. The initial stage of colonization by HCM on *Leptocereus quadricostatus* is characterized by a powdery wax-like white spot on the areole (A) or/and bending of the branch (B). (Scale bar = 3 cm).

After this initial infestation stage, we observed other morphological growth changes and abnormalities on the cactus host. The infested areole starts to develop new vegetative growth that looks like a new ramification bud (Fig 3A). This bud later, due the persistent feeding of HCM, becomes something different, a gall. The initial stage of gall formation seems uniform for all the plants. A gall is the result of abnormal growth of plant tissue promoted by a parasite, in this case HCM. We first observed this type of abnormality at 97 days from the initial infestation event. These galls were observed at the apex and branch sides, but the ones that continued further development were localized mostly on secondary and tertiary branches, which were younger, less lignified tissues and still actively growing.

Although there is a lot of variability in the morphology of the galls observed in *L. quadricostatus*, four types of gall structure were commonly observed.

1. The gall stays as small-deformed bud with minimal growth and with one or little new ramification. Most of the cases the small-deformed bud is densely covered with the powdery wax-like material secreted by the mealybug. In many cases this is observed in primary branches (Fig .4-1A, 4-1B).

2. The bud grows multiple small ramifications that are densely packed forming a type of rounded tumor or gall. The density of spines in the areole is higher than in non-infested cacti. (Fig. 4-2A, 4-2B).
3. The bud elongates as a thin and deformed "branch" which later starts to show multiple branching at the apex of the new branch while gall growth develop similar to type 2 galls (Fig. 4-3A, 4-3B).
4. As a result of the initial curling of the branch, the branch continues to curl. The infested areole that initiated the curling develops a bud that results in abnormal growth of branches resulting in galls similar the type 2 galls. This gall is localized in a protected area inside the curl (Fig. 4-4A, 4-4B).

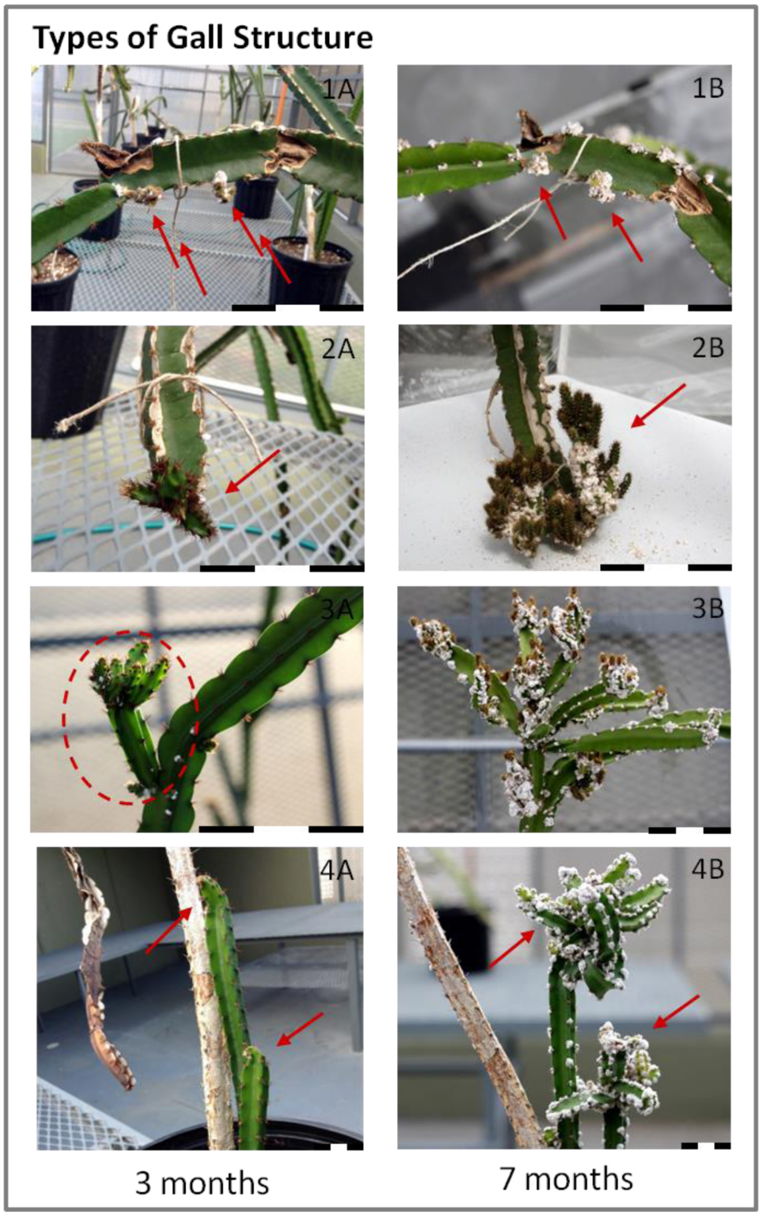

Figure 4. Gall development during initial colonization stages by HCM on *Leptocereus quadricostatus*. (Scale bar = 3 cm).

Although this is the first time the HMC infestation has been reproduced under control condition, gall induction has been documented in naturally occurring populations in other studies and in other cacti species (Segarra-Carmona 2010, Zimmerman 2010). It is also important to mention that that it seems that HCM feeding on plant extremities probably provokes hormonal imbalance and loss of apical dominance, which induces development of new lateral branches that will serve as new colonization sites for the pest insect.

Conclusions

The establishment of HCM under greenhouse conditions on *L. quadricostatus* was successful, inducing gall formation that were similar to some observed in naturally occurring plants infested by the pest. In addition, this plant could be easily propagated in a greenhouse and making it a viable alternative approach to rear abundant population of the pest insect, which could serve to study the pest-host interaction as well as natural enemies efficiencies for biological control. HCM colony establishment occurred in a relatively short time (1.5 month). We were able to identify various morphological alterations cause by the pest insect on the plant. Also we observed what it seems to form four (4) different types of gall development. These results provide a better understanding of the interaction between HCM and the endangered host plant *L. quadricostatus*, and may help develop more effective management strategies for the pest insect, as we continue to investigate tri-trophic interactions between the pest insect, host plant, and potential biological control agents.

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EFFECT OF BIO-STIMULANTS ON THE YIELD PERFORMANCE OF ORGANICALLY-GROWN EGGPLANT CULTIVARS IN THE U.S. VIRGIN ISLANDS

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Abstract: Crop bio-stimulants derived from commercial marine algae extracts have been known to improve yields in fruits and vegetable crops in conventional production system. Therefore, studies of biostimulants in organic management system are needed to determine their potential impact on yield. In organic management system ten cultivars of eggplant (Nubia, Fairy Tale, Dancer, Beatrice, Calliope, Orient Charm, Barbarella, Rosa Bianca, Machiaw and Shooting Stars) were selected to evaluate bio-stimulant effect. Ten cultivars of eggplant (*Solanum melongena* L.) were treated weekly with Stimplex® (5 mL/L) (liquid seaweed extract of *Ascophyllum nodosum*) and Biozest® (20 mL/L) crop bio-stimulants as foliar spray. Half of the plants in a row (5 plants) were sprayed weekly and the other half of the plants (5 plants) were untreated as a control. The organically managed, experimental design was a randomized complete block with 3 replications consisting of rows spaced 3' apart with plants spaced 2' between each plant within a row. Results showed that Stimplex® treated plants performed better than biozest treated plants. Marketable yields were higher in Stimplex® treated plants of Nubia (10.7%), Fairy Tale (42.5%), Dancer (31.9%), Beatrice (27.8%), Barbarella (13.9%), Machiaw (84.2%) and Shooting Stars (9.9%) than their respective untreated controls. Higher marketable yields were obtained in Biozest® treated plants of Nubia (35.8%), Beatrice (10.3%), Orient Charm (1%), Rosa Bianca (68.8), and Shooting Stars (55%) relative to their respective untreated controls. The remaining cultivars produced lower or non-significant yields. These results suggest that bio-stimulants may increase yields in eggplant. Additional research trials are needed to fully explain the effects of bio-stimulants in organically managed commercial production of eggplant.

Introduction

Eggplant (*S. melongena* L.) is a highly valued vegetable crop grown for fresh market in the Virgin Islands and the rest of the Caribbean (Palada *et.al.* 2000). The production of eggplant in the Virgin Islands increased from 19,495 lbs in 2002 to 37,163 lbs in 2007 (Census of Agriculture, 2009). The Government is encouraging locally grown produce to reduce the cost of imported food crops (Dominique 1990). Crop bio-stimulants derived from commercial marine algae extracts have been known to improve yields in fruits and vegetable crops in conventional production system. Therefore, studies of bio-stimulants in organic management system are needed to determine their potential impact on yield.

Studies show that organic management system have played a significant role in U.S. market expansion. The conversion of conventional farming to organic farming systems has been more extensive. U.S.-certified, organic-crop acreage more than doubled between 1992 and 1997, and doubled again between 1997 and 2001 for different crops (Greene and Kremen, 2003). According to the telephone survey by Food Marketing Institute (52 percent in 2004), (50 percent in 2003), and (53 percent in 2000) surveyed had purchased organic food. The Hartman Group study of 5000 consumers, “Organic food and Beverage Trends 2004” found that 66 percent of households purchased organic products. Furthermore, they reported that 56 percent of the people surveyed were buying the organic food because of the positive environmental impact from growing organic food (Shively, 2005).

Trial was conducted to evaluate the response of eggplant to the different chemical. An experiment was conducted on the eggplant responses to K fertilization on soil testing low in Mehlich-1 extractable K at live Oak, Fla, in the spring and fall of 1991. Fresh petiole-sap K critical concentration were 4500-5000 v/v before harvesting and 4000-4500 at the end of harvesting. Less than 3500 mg K/liter in fresh sap indicated K deficiency in the plant. Eggplant yielded 51.1 $t{\cdot}ha^{-1}$ with 94 kg K/ha fertilization in spring and 53.3 $t{\cdot}ha^{-1}$ with 60 kg K/ha in fall. Yield responses showed that the two sites differed in fertilization requirements (Hochmuth et al, 1993).

An experiment was conducted to evaluate the effect of tillage and insecticide treatment in growth and productivity of different cultivars (Ichiban, Little fingers, and Millionaire) of eggplant at Belleville, Illinois. Imidacloprid resulted in high total and early yield by controlling the damage from the flea beetle. The tillage method did not affect the eggplant productivity or the flea beetle effect. Cultivar performance was similar over the tillage method and insecticide treatment. Cultivar ‘Millionaire’ and ‘Ichiban’ provided higher marketable and total yield than ‘Little Fingers’ under same cultural practices (Range et al, 2010).

Materials and Methods

The experimental design was complete randomize block and four replication (Biozest® and Stimplex® treated) and a control for each cultivar. Biozest® and Stimplex® (8.75ml/gallon) and (46 ml/ gallon), respectively for two plots with 5 plants in each plot applied a day prior to transplanting eggplants into the field. Data on number of fruits, total yield, marketable yield, fruit weight, marketable fruits, and fruit size were recorded.

This study was conducted at the Albert A. Sheen campus of the University of the Virgin Islands Agricultural Experiment Station in fall season of 2012. The soil was sandy loam with 2% organic matter and pH 8.0. Seeds of cultivars ca. Nubia, Fairy Tale, Dancer, Beatrice, Calliope, Orient Charm, Barbarella, Rosa Bianca, Machiaw and Shooting Stars were obtained from Johnny Selected Seeds Co., NY and planted in seed trays (Styrofoam, 72 wells each). Trays were filled with pro-mix (Sun Grow Horticulture Canada Ltd.) and kept in the greenhouse for germination.

The field was rototilled and disk/harrowed. Twine was used to mark out the plots and colored flags (blue and orange) used to identify and differentiate the plots for the treated and the control. Seedlings were transplanted in the field approximately week after germination. Plots consisted of three rows spaced 4’ apart, with 12 plants per row spaced 2’ between the plants within a row using a drip system. The experimental design was randomized complete blocks, with 3 replications. Data collected from ten plants (#2-11) from centre row on maturity, number of fruits, total yield, marketable yield, and fruit size, fruit weight, marketable fruits. Fields were scouted and monitored for insect pests and diseases by Extension entomologist periodically. A complete fertilizer 20-20-20 was applied during the experiment through drip irrigation system (fertigation), weekly or as needed.

Plants of ten cultivars of eggplant (*Solanum melongena* L.) treated weekly with Stimplex® (5 mL/L) (liquid seaweed extract of *Ascophyllum nodosum*) and Biozest® (20 mL/L) crop bio-stimulants as foliar spray. Complete randomized block design with three replicates in each cultivar used. A total of 30 plots (three of each cultivar) were used, where each plot consists of three rows.

The left rows were treated with Stimplex® and right ones were treated with Biozest® while the center rows were considered as untreated or control-data rows in each plot. Stimplex® and Biozest® were applied 2 days prior to transplanting with a backpack sprayer. A total of 108 plants (36 plants/plot) of each cultivar were transplanted and watered after transplanting.

Collection of Data

Data was collected on the yield produced by all ten eggplant cultivars. Fruits were harvested when mature and measured, weighed, and graded. Marketable fruit weights will be considered to be at least 2.3 kg. The marketable yield (number of fruits and average fruit weight) was determined.

Experimental Design and Statistical Analysis

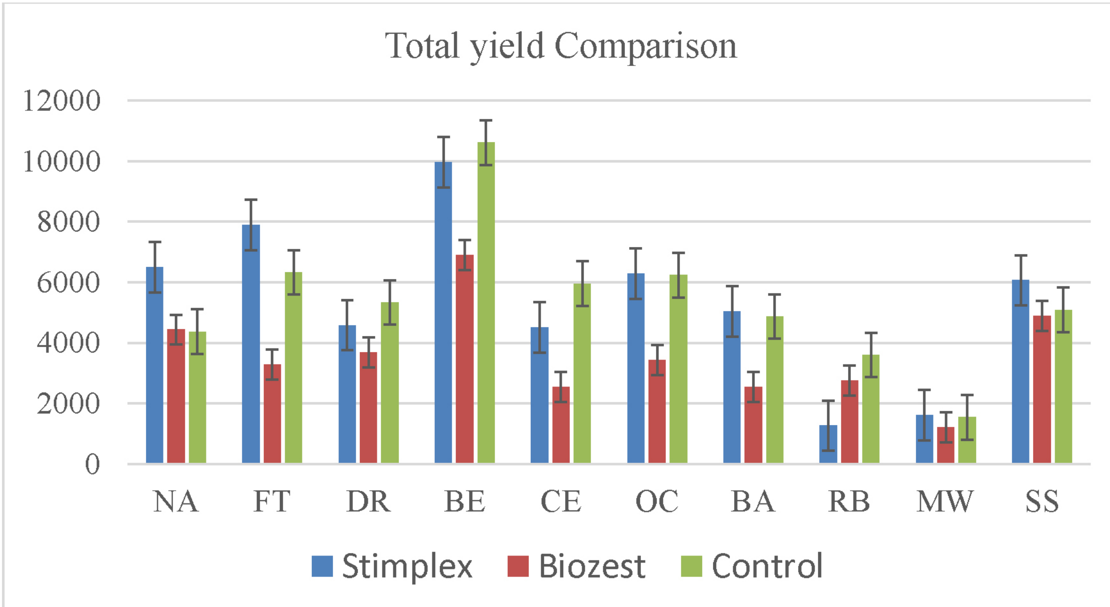
Experimental plot arranged in a randomized complete block design with three replications of each cultivar as explained in Materials and Methods. Each set of experimental data were analyzed using one way analysis of variance. There are separate analyses of weights, quality, yield and weed count. Treatment means were compared using Fisher's protected LSD tests at $P < 0.05$ for significance.

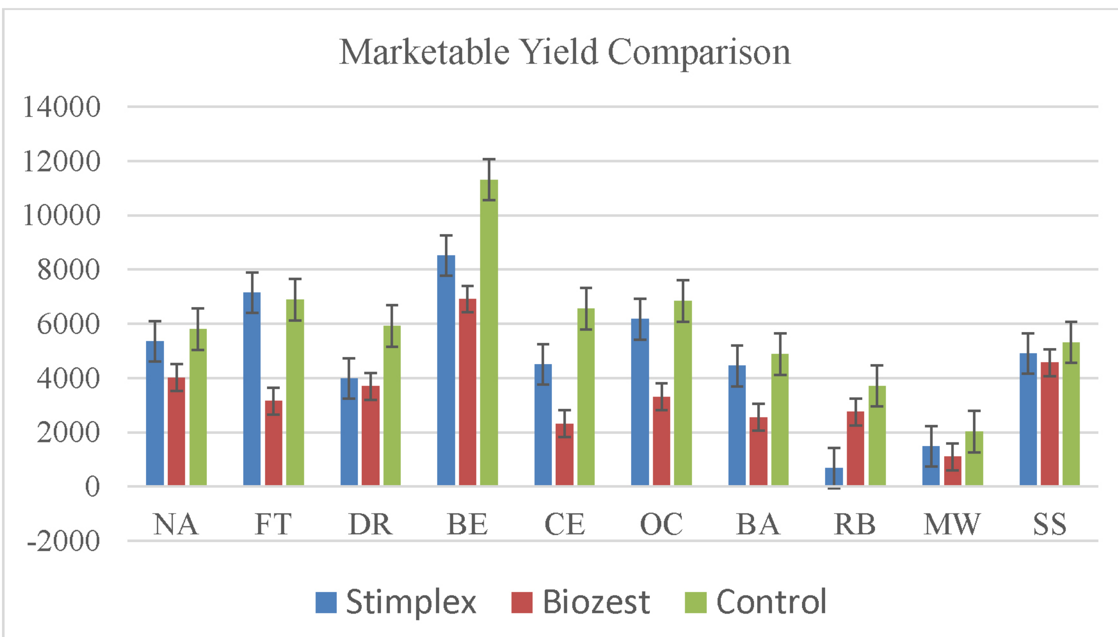
Table 1. Fruit weight (g) of eggplant varieties treated with biostimulants and control (untreated)

Varieties	Stimplex	Biozest	Control
Nubia (NA)	319.72	112.55	341.05
Fairy Tale (FT)	42.42	49.70	44.30
Dancer (DR)	217.22	214.08	216.38
Beatrice (BE)	319.32	242.80	262.40
Calliope (CE)	160.03	162.46	208.66
Orient Charm (OC)	127.58	123.27	131.91
Barbarella (BA)	211.01	229.38	281.08
Rosa Bianca (RB)	336.4	549.1	528.53
Machiaw (MW)	104.25	124.99	104.28
Shooting Stars (SS)	149.70	167.13	153.03

Results and Discussion

Increment in fruit yield, number of fruits and fruit weight was observed in Stimplex® and Biozest® treated plots. In Stimplex® treated plots, higher yields were produced in cultivars Fairy Tale 42.1%, and Machiaw 59.33% but lower yields in Calliope (40.01%) were produced relative to their respective controls (untreated cultivars). Cultivars treated with Biozest®, Rosa Bianca 68.85%, and Shooting Stars 58.09% produced higher yield and lower in Calliope by 70% than untreated. Yields were significantly higher in all ten cultivars grown in Stimplex® treated plots. 'Nubia' produced highest yield (427.47kg/ha) and lowest in 'Calliope' (187.33kg/ha). The number of average marketable fruits was higher (55.20%) in Stimplex® treated plants compared to untreated plants (control) in Machiaw. Total fruit number was also higher (41.77%). Fruit weight was highest in Biozest® treated plants (549.1 gm) in comparison to untreated control plants in Rosa Bianca cultivar.





Conclusion

Stimplex® results were more suitable than the Biozest® for each cultivar in eggplant in the USVI study. High total yield, marketable yield with greater fruit size were observed in Stimplex® treated cultivars such as Nubia (10.7%), Fairy Tale (42.5%), Dancer (31.9%), Beatrice (27.8%), Barbarella (13.9%), Machiaw (84.2%) and Shooting Stars (9.9%) than control. Higher marketable yields were obtained in Biozest® treated plants of Nubia (35.8%), Beatrice (10.3%), Orient Charm (1%), Rosa Bianca (68.8), and Shooting Stars (55%) relative to their respective untreated controls. Cultivars produced lower or non-significant yields in remainder of cultivars. These results suggests Stimplex® out performs Biozest® and is economical and suitable as a Bio-stimulant for eggplant production in the US Virgin Islands, however, further study is needed before adopting this practice.

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