COCOA RESEARCH CENTRE

ANNUAL RESEARCH AND DEVELOPMENT SYMPOSIUM

Cocoa Research Centre
The University of the West Indies, St. Augustine Campus

Deconstructing elements of "Terroir" to support branding and niche marketing of cocoa

Wednesday May 8th 2019
8:00 am - 4.30 pm
Institute of Critical Thinking,
2nd Floor, CLL Building, The UWI, St. Augustine Campus

PROGRAMME - OPENING CEREMONY

8:00 – 8:30 REGISTRATION

8:30 – 8:35 Chair

Prof. Path Umaharan – Director, Cocoa Research Centre

8:35 – 8:40 Welcome Remarks

Prof. Brian Copeland – Principal, The UWI St. Augustine Campus

8:40 – 8:45 Remarks

Mr. Derek Luk Pat - Executive Director, Trinidad and Tobago Bureau of Standards

8:45 – 8:50 Remarks

Senator the Hon. Paula Gopee-Scoon - Minister of Trade and Industry.

8:50 – 9:15 Feature Address

Senator the Hon. Clarence Rambharat – Minister of Agriculture, Land and Fisheries.

9:15 – 9:20 Improving cocoa quality via standards – Power point presentation

Ms. Adrienne Stewart, Standards Officer, Trinidad and Tobago Bureau of Standards

9:20 - 9:30 Presentations

Presentation of Standards by Senator the Hon. Paula Gopee-Scoon - Minister of Trade and Industry

Other presentations

9:30 – 10:00 **COCOA BREAK**

BRANDING AND TRACEABILITY TO SUPPORT NICHE MARKETING
Moderator: Ms. Karen Lee Lum

10:00 – 10:15 Connecting the dots in support of building a sustainable cocoa sector.
Pathmanathan Umaharan

10:15 – 10:30 Profiling quality attributes of selected cacao genetic clusters at the ICGT – a basis for flexible postharvest approaches.
Naailah Ali*, D.A. Sukha, S. Mujaffar and P. Umaharan*

10:30 – 10:45 Cocoa flavour mapping across agro-ecological zones towards identifying flavour niches to support ultra-niche marketing.
Darin Sukha, *N.A. Ali, S. Ramkissoon, M. Lewis, K. Maharaj, V. Lall and P. Umaharan*

10:45– 11:00 Optimising the use of Near Infrared Spectrometry for monitoring cocoa bean quality and traceability in Trinidad and Tobago.
Vickeisha Lall, *D.A. Sukha, N.A. Ali and P. Umaharan*

11:00 – 11:15 Building an 'E-traceability platform' to support niche marketing of Trinidad and Tobago cocoa.
Darin Sukha, *M. Lewis and P. Umaharan*

11:15 - 11:30 Support for building a value added sector – branding Trinidad and Tobago cocoa.
Karen Lee Lum, *D.A. Sukha and N.A. Ali*

11:30 - 11:45 The International Fine Cocoa Innovation Centre (IFCIC) Chocolate Incubation Model.
Julian Henry *and K. Lee Lum*

11:45 – 12:15 Discussion

12:15 – 1:30 **LUNCH BREAK**

IMPROVING FARM LEVEL PRODUCTIVITY
Moderator: Dr. Darin Sukha

1:30 – 1:45 Phenotypic diversity studies at the Cocoa Research Centre (CRC): retrospective and prospective vignettes.
Frances L. Bekele*, G.G. Bidaisee and J.J. Bhola*

1:45 – 2:00 Exploring the wild side of cocoa.
Lambert A. Motilal*, D. Gopaulchan, A. Sankar, A. Mahabir, K. David and R. Umaharan*

2:00 – 2:15 Managing soil fertility to improve cocoa productivity in Trinidad.
Kamaldeo Maharaj*, M. Lewis and P. Umaharan*

2:15 – 2:30 Discussion

2:30 – 2:45 **COFFEE BREAK**

RISK AND CONSTRAINT MANAGEMENT
Moderator: Ms. Frances Bekele

2:45 – 3:00 Mitigating and managing risks in the cocoa industry using a GIS approach
Marvin Lewis

3:00 – 3:15 Understanding the distribution of bean cadmium levels in Trinidad and Tobago
Amrita Mahabir, *M. Lewis and K. Maharaj*

3:15 – 3:30 Use of soil amelioration and cultural strategies to mitigate Cadmium in cocoa
Gideon Ramtahal*, P. Umaharan*

3:30 – 3:45 Evaluating cadmium bioaccumulation in cocoa
Caleb Lewis, *A. Lennon, G. Eudoxie and P. Umaharan*

3:45 – 4:00 Organic cocoa – towards developing biological control options for disease control in Trinidad
Reuben Jean Louis*, D. Saravanakumar, G.M. ten Hoopen*

4:00 – 4:15 Discussion

4:15 – 4:30 Summary and conclusions
PathUmaharan

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ABSTRACTS

Profiling quality attributes of selected cacao (*Theobroma cacao* L.) Genetic clusters at the International Cocoa Genebank Trinidad (ICGT) - A basis for flexible postharvest approaches

Naailah Aminah Ali [a,b], Darin Sukha[a], Saheeda Mujaffar[b] and Pathmanathan Umaharan[a]
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There is an intrinsic variability in cacao production and postharvest processing which impacts on final product quality. One source of variability is genetics and its influence on pulp and bean characteristics which can affect fermentation progression and final flavour expression. This study utilised six cacao genetic clusters (Iquitos, Nanay, Nacional, Contamana, Amelonado, Marañón), grown and processed under the same conditions at the International Cocoa Genebank Trinidad (ICGT) and University of the West Indies, St. Augustine, respectively, to investigate: (i) the role of genetic differences on fermentation activity as well as chemical and sensory quality; (ii) the distinctiveness of the genetic flavour potential of the various genetic groups and (iii) the crop year effect on fermentation dynamics and final flavour. Fermentations were replicated both within each year and over three years and carried out in Styrofoam containers as previously described. The fermenting cacao mass was monitored during the fermentation period for temperature, pH, soluble solids, fermenting bean colour and fissuring. After drying, cocoa bean attributes such as bean count, bean weight and dimensions, polyphenols, purines, acids, flavour volatiles and sensory attributes were also profiled. There were significant genetic differences ($P<0.05$) in both sensory and chemical profiles with some genetic groups (e.g. Amelonado and Contamana) requiring shorter fermentation time than others to express their genetic flavour potentials. Significant crop year ($P<0.05$) and crop year × genetic cluster ($P\leq0.05$) effects were also observed for fermentation temperature, colour of beans (L,a,b) and acids (citric and succinic); as well as for the following flavour attributes: astringent, over fermented, cocoa and floral notes ($P\leq0.01$). This study demonstrates the potential for harnessing the various sensory attributes available within cacao's genetic diversity thereby establishing a basis for genetics-based branding and branding according to vintage (crop) years. The results strengthen the argument for flexible postharvest approaches rather than having fixed fermentation times. It also underscores the importance of making processors aware of industry requirements and international standards as well as equipping them with the necessary skills to identify fermentation cues to optimise cacao fermentations.

Keywords: cacao; cocoa; genetic clusters; Iquitos; Nanay; Nacional; Contamana; Amelonado; Marañón; quality; postharvest; fermentation.

Cocoa Flavour mapping across agro-ecological zones towards identifying flavour niches to support ultra-niche marketing

Darin Sukha, Naailah Ali, Saila Ramkissoon, Marvin Lewis, Kamaldeo Maharaj, Vickeisha Lall, and Pathmanathan Umaharan
Cocoa Research Centre, The University of the West Indies.

Trinidad and Tobago is one of only eight countries recognised in Annex C of the International Cocoa Agreement (2010) as an exclusive producer of 100% fine or flavour cocoa. Previous research has established the basis for applying the concept of "Terroir"[1] to cocoa and has shown that a combination of genetics, growing and processing environment and practices contribute to the unique sense of place in the expression of flavour potential of cocoas from different origins. The study investigated whether within Trinidad and Tobago there are opportunities to exploit flavour niches that produce distinctive flavours with the overall aim to diversify the variety of offerings to ultra-niche markets. In the study pre-inoculated cocoa beans were collected from 6-7 representative farms from each of the seven agro-ecological regions. The samples were processed using a standard postharvest methods using Styrofoam® coolers at a single location. These zones represent unique combinations of genetics, growing environments and microflora all of which can result in the expression of interesting flavour potentials. The flavour map presented is based on sensory assessment of beans obtained from the first set of 24 farms assessed as part of the IMPACTT project towards Improving the Marketing and Production of Artisanal Cocoa from Trinidad and Tobago. Together with careful quality control, certification, and traceability the flavour map presented can facilitate the branding of cocoa beans from different regions of Trinidad to give cocoa farmers a competitive advantage when targeting niche international markets.

Keywords: Terroir, flavour, cocoa, quality, certification, traceability

[1] "Terroir" is concerned with the relationship between the characteristics of an agricultural product (quality, taste, style) and its geographic origin, which might influence these characteristics. This concept has been well documented in viticulture as the sensory attributes of wine have been related to the environmental conditions in which the grapes are grown.

Optimising the use of Near Infrared Spectrometry for monitoring cocoa (*Theobroma cacao* L.) bean quality and traceability in Trinidad and Tobago

Vickeisha Lall, Darin Sukha, Naailah Ali and Pathmanathan Umaharan
Cocoa Research Centre, The University of the West Indies.

Near Infrared Spectroscopy (NIRS) has been routinely used as a fast and non-destructive technique to identify chemical constituents in food and agricultural products through the development of characteristic spectral fingerprints. The Cocoa Research Centre is attempting to use this technology to aid (a) in predicting cocoa bean quality and (b) to support traceability using cocoa beans or cocoa liquor. Two experiments were carried out. The first investigated the effectiveness of using NIRS to detect differences in fermentation levels, while the second investigated the ability of NIRS to detect differences of cocoa produced in different geographical regions. Sensory analysis is part of cocoa quality assessment and is used to detect off flavours resulting from postharvest processing defects. To reduce the cost associated with training and commissioning sensory panels, NIRS was investigated as an alternative. Near-infrared spectral scans of 72 cocoa liquor samples (from the RDI project) produced from unfermented, partly fermented and fermented beans were subjected to NIRS analysis. The results show that the near infrared spectra is able to discriminate between these three bean quality classes. Further work will entail building an identification model to predict cocoa bean class (unfermented, partly fermented and fermented) for both cocoa liquor and cocoa beans. In the second experiment, Near-infrared spectral scans of 18 different cocoa bean samples from the five agro-ecological zones of Trinidad and Tobago were subjected to NIRS analysis. Preliminary results are promising. Spectral scans of more samples from each zone are being done to develop a reliable prediction model. Expanding and adapting the use of NIRS technology in predicting cocoa bean quality as well as for traceability bolsters the quality management and certification activities of the Cocoa Research Centre.

Keywords: Quality, traceability, cocoa beans, fermentation levels, geographic regions

Building an 'E-Traceability Platform' to support niche marketing of Trinidad and Tobago cocoa (*Theobroma cacao* L.)

Darin Sukha, Kamaldeo Maharaj, Marvin Lewis and Pathmanathan Umaharan
Cocoa Research Centre, The University of the West Indies.

The cocoa value chain represents the journey of cocoa beans from the tree or farm through the post-harvest handling steps to the dried bean in a warehouse ready to be used for chocolate making. As the name implies, value or the price potential accrues at each stage along this chain that is often times not very well defined, understood and convoluted with many varied players. The activities at these critical steps in the value chain has an indelible impact on physical, chemical, and microbial quality attributes as well as on the expression of genetic flavour potential of the varieties used. Therefore, it is important to track events that occur along the critical control points in the chain of custody for each player to derive a better understanding of final quality and expressed "terroir". The Cocoa Research Centre has developed a novel e-traceability platform that integrates farm certification, quality certification to support niche marketing of Trinidad and Tobago cocoa. Phase-1 of the platform has been completed as part of the IMPACTT project towards Improving the Marketing and Production of Artisanal Cocoa from Trinidad and Tobago. Key elements of this platform include: i) a flexible platform recognising various cocoa value chains existing in the cocoa sector; ii) an easy user interface that works with any internet enabled device with clickable data entry templates capturing relevant information at each stage in the value chain; iii) traceability data linked to Quick Response (QR) codes at each stage in the value chain; iv) easy linkages to quality certification systems and E-marketing platforms for niche marketing. This novel traceability platform adds critical information towards our understanding of "terroir" and is currently being beta tested. It has the potential to revolutionise quality certification and niche marketing of Trinidad and Tobago cocoa, and through this improve income of cocoa farmers.

Keywords: Terroir, traceability, value chain, quality, certification

Support for building a value added sector-Branding Trinidad and Tobago Fine or Flavor Cocoa.

Karen Lee Lum, Darin Sukha, Naailah Ali
Project Manager Cocoa Research Centre

The International Fine Cocoa Innovation Centre (IFCIC) has as its strategic plan mechanism and channels for building commercially viable structures that enables the entire cocoa value chain, beyond the borders of Trinidad and Tobago and IMPACTT as one such vehicle. Historically, TT cocoa has been recognized as a premier geographic location of fine or flavor cocoa and consistently retains our global position of being one of only eight countries with the status of 100% exclusive producer of fine or flavor cocoa (ref.: ICCO).
The question is "how do we effectively monetize this position", to the benefit of all the players along the value-chain. We innovate, we optimize, we demonstrate modern state-of-the-art and sustainable practices, build quality into every process, measure, evaluate and BRAND, simply and consistently until our brand becomes synonymous with cocoa.
… We brand by single estate for its providence, uniqueness, identifiable and repeatable consistency and practices
… We brand by geographical indications, where a community-area-region is immediately recognized for its distinctive qualities, its unique history, cultural practices and geographic origin
… We brand by country when we can demonstrate more than 85 years of excellence in cocoa research and development, curation of the world's largest cocoa gene bank and home of the world famous Trinitario
… We brand into every bean traceability, consistent high quality and flavor.

Keywords: IFCIC, IMPACTT, UWI-CRC, fine/flavor cocoa, value-added, ultra-niche (boutique), commercialization, branding, GIs.

The International Fine Cocoa Innovation Centre (IFCIC) Chocolate Incubation Model

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The International Fine Cocoa Innovation Centre (IFCIC) is an EU/ACP project that is designed to support and strengthen the entire cocoa value chain towards accessing high value niche and ultra-niche markets. The physical facility being built will consist of a model orchard, cocoa processing facility, a chocolate factory, business and technology incubators, certification laboratories and product development and training facilities. In this regard the incubator component is a key aspect of the downstream development drive that will allow new entrants as well as existing producers in the local industry to develop and refine cocoa innovations and innovative business models towards commercial viability. This presentation outlines the process (and advantages) of IFCIC's Incubation initiative and provide's some context on how this can be a pivotal driver towards strengthening the local Cocoa Industry.

Keywords: Technology, incubators, cocoa beans, chocolate, business plan

Phenotypic diversity studies at the Cocoa Research Centre (CRC): retrospective and prospective vignettes

Frances L. Bekele, Gillian G. Bidaisee and Junior J. Bhola
Cocoa Research Centre, University of the West Indies, St. Augustine

Morphological characterisation has been a core activity at CRC for more than 25 years. It has facilitated an understanding and universal appreciation of the rich cacao genetic diversity conserved at the International Cocoa Genebank Trinidad (ICGT). There are several superior genotypes (primary and enhanced) that combine favourable yield potential, seed size and other desirable traits. They may possess putative adaptation to abiotic stress (such as water deficit) since they seem to be flourishing under a low input system where water availability may not meet the monthly recommended requirement of 100 mm during the dry season. These genotypes and the diverse cacao collection are at the disposal of the international cocoa community. They can be used to improve cacao planting material to increase production and productivity and, subsequently, living income generation within cocoa communities. This presentation focuses, retrospectively, on the contribution of morphological characterisation and considers the way forward to maximise the benefit of this painstaking and vital activity at CRC, in light of the ICGT's custodial role in safeguarding the future of the global cocoa industry. With the advent of whole genome sequencing, unravelling associations between phenotypic traits of interest and genetic markers will enable us to finally make unprecedented progress in genetic improvement of cacao through genomic selection (GS) and GS-marker-assisted selection.

Keywords: cacao, cocoa, genomic selection, living income, marker-assisted selection, morphological characterisation, phenotypic diversity, production, yield potential

Exploring the wild side of cocoa.

Lambert A. Motilal, David Gopaulchan, Antoinette Sankar, Amrita Mahabir, Kadine David and Romina Umaharan.
Cocoa Research Centre, The University of the West Indies, St. Augustine

Cacao trees are well known to the stakeholders of the cocoa industry, but the wild relatives of cacao less so, due in part to their generally low economic value with possible exception of *T. grandiflorum*. In addition, the genetic diversity of the wild relatives remains relatively unexplored. In describing the diversity of cacao, geneticists often construct phylogenetic (family) trees to show the relationships among different accession groups and population groups. These phylogenetic trees are usually presented without an outgroup, which may prevent the true evolutionary relationships from being displayed. We examined the genetic diversity of wild types (*Herrania* spp. and *Theobroma* spp.) present at CRC using single nucleotide polymorphisms (SNPs). A substantial amount of SNP markers (77%; 135 of 175) could be amplified in the wild species suggesting that the SNP primer binding sequences were conserved among these different genomes. Small differences were observed within the *Herrania* and wild *Theobroma* species, with the majority of the individuals being different at 1-9 and 1-13 SNP markers respectively. Individuals in these two main wild groups were generally homozygous. Nevertheless, *Herrania*, wild *Theobroma* allies and *T. cacao* populations and accessions could be distinguished from each other using multivariate analysis, phylogenetic analysis and ancestral analysis. This is the first known study to position the wild relatives of cacao with the ten accepted populations of *T. cacao* using SNP markers. The use of a wild relative to root phylogenetic trees in cocoa, the mapping of the genomes of the wild relatives and the use of the wild types to improve farmed cacao are recommended.

Keywords: Wild Types, SNP, genetic diversity, Herrania, Theobroma species, outgroup, ancestry, cocoa

Managing soil fertility to improve cocoa productivity in Trinidad

Kamaldeo Maharaj, Marvin Lewis and Pathmanathan Umaharan
Cocoa Research Centre, University of the West Indies, St. Augustine

There is a wide productivity gap between the current average cocoa yield of 150 kg ha^{-1} and the potential yield of 1500 kg ha^{-1}. With improved management such as pruning, shade and disease control, cocoa farms have achieved over 300 kg ha^{-1}. It is important to understand the soil deficiencies and replenish the deficient nutrients to further improve yields. The objective of the study was to investigate the fertility across the 6 agro-ecological zones (AEZ) and the constituent 43 cocoa communities to identify soil fertility problems. Using a stratified sampling technique 250 farms of the 1163 registered cocoa farms were surveyed over two years for soil fertility by the Cocoa Research Centre. The first phase involved 46 farms located over the six cocoa AEZs identified for Trinidad. The results identified general trends that were a problem across the country and specific soil fertility issues that were peculiar to specific AEZs or cocoa communities. The general trends were (a) declining soil pH (<5.5) and CEC values (b) critically low levels of Nitrogen and Potassium and (c) low levels of Boron. In addition, specific cocoa communities had low Phosphorus content, low Sulphur, low Zinc or low Copper. Cocoa along with companion crops have been grown and products harvested and removed for over 80-100 years without replenishing the soil nutrients. This along with soil erosion, leaching and flooding events possibly resulted in the high levels of impoverishment of cocoa soils. The soil fertility management therefore requires general recommendations such as liming, as well as use of an inorganic fertilizer mixture that overcomes the generic soil deficiencies supported by region specific recommendation of supplementary nutrients. An integrated strategic soil fertility management approach will be used to supply inorganic nutrients over four growth stages according to the 4R Stewardship Principle (Right Source, Right Rate, Right Time and Right Place) to overcome deficiency, while taking into account crop nutrient removal values. It also recommends liming, organic matter addition and other good agricultural practices. Caution must be exercised to ensure that cadmium is not present in the fertilizers used.

Keywords: Soil testing, nutrient depletion, fertility management

Mitigating and managing risks in the cocoa industry using a GIS approach

Marvin Lewis
Cocoa Research Centre, The University of the West Indies, St. Augustine.

The cocoa industry of Trinidad and Tobago has an enormous potential to become an important economic diversification option for Trinidad and Tobago. Research and development efforts are critical to modernize the cocoa industry and improve the profitability of cocoa farms so that they become attractive investment options. There are numerous constraints and risk that the cocoa farmer face that can affect profitability and the cost of production. Most of these factors are not at the country level but rather at the subregional, community or farm level. This study seeks to use a GIS approach to identify, quantify and model the multiple risk factors with the aim to develop cost of production and business models for farms in different parts of the countries. This will allow governments and NGOs to prioritize support, R&D institutions to develop appropriate technologies to mitigate risks and private sector to make investment decisions. The study uses a stratified multilayer sampling approach, where risks/ constraints affecting 170 farms will be mapped into the forty two (42) cocoa growing communities and into the six (6) agro-ecological zones, where cocoa is cultivated in Trinidad. The data will be acquired from existing information, new research data being generated under the IMPACTT Project (Improving the Marketing and Production of Artisanal Cocoa from Trinidad and Tobago) which is funded by the Inter-American Development Bank Multilateral Investment Fund (IDB) and through farmer surveys. Geospatial analysis provides spatial awareness for observations, providing greater insights thereby increasing the applicability of such factors. The methodology shall involve the use of a Geographic Information System (GIS) framework for data capture, data modelling, overlay analysis and geostatistical analysis. This information can be further modelled to develop region specific cost of production models taking into account cost of risk mitigation. The Research is intended to produce a Risk Map, a Risk Management Map and a Predictive Cost of Production Map for the Trinidad cocoa industry.

Keywords: Geographic Information System, Geostatistical Analysis, Risk Management, Cost of Production

Understanding the distribution of Cadmium in Trinidad and Tobago

Amrita Mahabir Marvin Lewis, Kamaldeo Maharaj
Cocoa Research Centre, The University of the West Indies, St. Augustine

Cadmium (Cd) is a known toxicant which accumulates in the human body during the life of a person and can be particularly detrimental to the bones and kidneys. It has also been associated with an increased risk of several types of cancer. Cadmium is a naturally occurring heavy metal associated with young volcanic soils but can also be a contaminant from anthropogenic sources. With the European Union regulations setting maximum allowable limits for cadmium in cocoa beans, it is important to identify contaminated regions, adopt appropriate and targeted approaches to mitigate Cd to ensure the sustainability of the cocoa industry. The present study is being undertaken by CRC in collaboration with the CDCTTL to determine the distribution and levels of Cd in cocoa beans. The cocoa growing areas in Trinidad fall into 6 agro-ecological zones which are further subdivided into 43 cocoa growing communities. Using a stratified proportional sampling approach 176 farms were selected from the 43 cocoa communities for the study, and from each farm, a representative sample of trees and pods were collected. The beans were aseptically removed, peeled, oven dried, subsampled and ground to represent the different farms at CRC's laboratory. The samples were digested and subjected to Cd analysis using ICP-MS. The results show that Cd is not randomly distributed and found in particular in the North East region and low-lying areas of East Trinidad. The total Cd varied from 0.09 to 8.0 mg kg^{-1}. The presentation will outline the cocoa communities to be targeted for amelioration, and the levels at which bean Cd is found in these communities. This will allow the cocoa communities to be further categorised into high medium and low contaminated regions towards administering appropriate approaches.

Keywords: *Theobroma cacao,* Cadmium, chocolate, heavy metal, maximum allowable limit

Use of soil amelioration and Cadmium strategies to mitigate Cadmium in cocoa

Gideon Ramtahal and Path Umaharan,
Cocoa Research Centre, The University of the West Indies, St. Augustine

Effective 1st January 2019, the European Union has implemented strict food safety standards regarding the levels of Cd in chocolate and cocoa products. A number of cocoa-producing countries who are affected by these regulations have started and continue to explore ways to reduce Cd concentrations in their beans. At the Cocoa Research Centre, mitigation strategies using various agronomic approaches have been undertaken. A greenhouse experiment using an organic material called Brewers' Spent Grain (BSG) to treat the Cd-contaminated soil of potted cacao plants yielded promising results. As the BSG rates increased there was a significant decrease in the levels of leaf Cd. At the highest rate of BSG application, the concentration of Cd in leaves demonstrated a significant decrease of up to 50% of the control. A field trial utilizing lime and biochar soil amendments has also demonstrated its effectiveness in reducing Cd uptake in cacao. Within the first four months of the experimental period, the application of lime significantly decreased the leaf Cd levels with the effectiveness increasing with each rate of application. Biochar was also effective in decreasing leaf Cd concentrations compared to the levels found in the control and was more evident at the higher rates of application with an average of 30% reduction. Coppicing was also was shown to significantly reduce the levels of leaf Cd.

Keywords: Cocoa, Cadmium, Amendments, Coppicing

Evaluating the factors of cadmium (Cd) uptake and bioaccumulation in *Theobroma cacao* L.

Caleb Lewis, Adrian Lennon, Gaius Eudoxie, and Pathmanathan Umaharan
Cocoa Research Centre, The University of the West Indies.

The many anthropogenic uses of heavy metals have resulted in the worldwide contamination of agricultural soils. Elevated soil levels of non-essential heavy metals, like cadmium (Cd), have led to increases in plant uptake, and the human dietary intake of these elements. The intake of Cd must be managed as it is considered toxic due to the associated health risks. Regulatory limits have been placed on the concentrations of Cd in foodstuffs that have been identified as key contributors to dietary exposure, and recently, the European Food Safety Agency has imposed a maximum allowable limit for Cd in chocolate products. The amount of Cd in cocoa beans has been found to be a function of the cadmium level in the soil, its availability to the cocoa tree and the genetics of the cocoa tree which affects the absorption and partitioning of Cd into the beans. With two aims; investigating the physicochemical characteristics of the soil that influence Cd uptake, and to identify cocoa genetic varieties with reduced Cd concentrations in the leaf and bean, two studies were performed. The first study was completed using five methods of soil heavy metal extraction across 15 cacao farms to assess the influence of six elements, and other physicochemical soil factors on cadmium uptake. The second study screened 100 accessions that represented the various genetic groups held at the International Cocoa Genebank in Trinidad (ICGT). The first study found the DTPA and Mehlich 3 extractable concentrations of Cd, Ni, and Zn, as well as soil pH to be the main soil factors that influence Cd uptake. The second study found a 7-fold and 13-fold difference in leaf and bean Cd concentrations, respectively. Partitioning of Cd between nibs and shells varied between accessions. These studies lay the foundation for reducing the Cd concentration in the cacao plant and the subsequent chocolate products.

Keywords: Cadmium, Cocoa, soil influence, genetic variation, maximum allowable limit.

Organic Cocoa - Towards developing biological control options for disease control in Trinidad

Reuben Jean Louis[1,2], Duraisamy Saravanakumar[1], G. Martijn ten Hoopen[2,3]

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[3] *CIRAD, UPR Bioagresseurs, CRC, Trinidad and Tobago. Bioagresseurs, Univ Montpellier, CIRAD, Montpellier, France.*

Trinidad is home to two of the big five of cocoa diseases, Witches' broom disease (WBD), due to *Moniliophthora perniciosa* and Black pod disease (BPD), due primarily due to *Phytophthora palmivora*. Both pathogens, similar to the farmers that grow them, love the high quality cocoa trees growing here and can cause substantial production losses if they remain unchecked. Although cultural control is the backbone for all control measures of cocoa pests and diseases, such measures are often time consuming, thus expensive, and sometimes complex. Chemical control, although fairly effective against some diseases, has major negative externalities and in the case of organic cocoa, which receives a premium on the world market, is simply not allowed, or at least severely restricted. Biological control is thus increasingly looked at as a viable alternative for cocoa pest and disease control. The objective of this study therefore, is to isolate and screen native biological control agents for the simultaneous control of WBD and BPD.
Biocontrol isolates belonging primarily to the genera *Trichoderma* or *Clonostachys* were isolated from soil and cocoa tissue samples. Mycoparasitic capacity of these isolates against the two pathogens was determined *in vitro* using the pre-colonized plate technique. The impact of volatile secondary metabolites on pathogen growth was determined through the double plate method. Results were analyzed using Anova.
Results indicate that there were marked differences between biocontrol agents with regard to mycoparasitic capacity ($P<0.0001$), independent of *Phytophthora* isolate used. Interestingly, there was a significant ($P<0.0001$) interaction between *Phytophthora* isolate and biocontrol agent for the impact of volatile secondary metabolites. Indicating that depending on the pathogen, biocontrol isolates differed in their capacity to reduce growth of the pathogen. *Trichoderma* isolates were most effective against *M. perniciosa*. The most consistent performing biocontrol agent overall seems to be CRC 10 (*Trichoderma* sp. leaf endophyte) which had good mycoparasitic capacity and produced volatile metabolites that reduced growth of both *Phytophthora* isolates and the *M. perniciosa* isolate effectively.
The most promising biocontrol agents will now be tested *in vivo* using detached pod and leaf assays. Ultimately field trials with the best performing BCAs will have to provide a product that will allow farmers in Trinidad to reduce diseases losses in a sustainable and ecologically sound manner.

Keywords: Disease, Biological control, mycoparasitic, *Phytophthora*, *Trichoderma*, *M. perniciosa*.

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