Investigative Research into Cadmium Levels of Cocoa Beans in Trinidad and Tobago

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Introduction

- Cocoa beans produced from our region are considered to be of fine flavour quality which can fetch premium prices on the world market.

- Recent trends in food safety has generated concerns about cadmium (Cd) in cocoa and cocoa products.

- **Cadmium: Adverse effects** on kidney, bone, immune and nervous systems.

- Increasing stringent regulations currently being proposed and enforced by international regulatory bodies.

EU Proposed Limits for Cd in Cocoa and Chocolate

Products	Limits (mg/kg)
Milk chocolate with <30% total cocoa solids	0.1
Chocolate between 30-50% total cocoa solids	0.3
Chocolate with ≥ 50% total cocoa solids	0.8
Cocoa powder sold to consumers (drinking chocolate)	0.6

Resultant Objectives

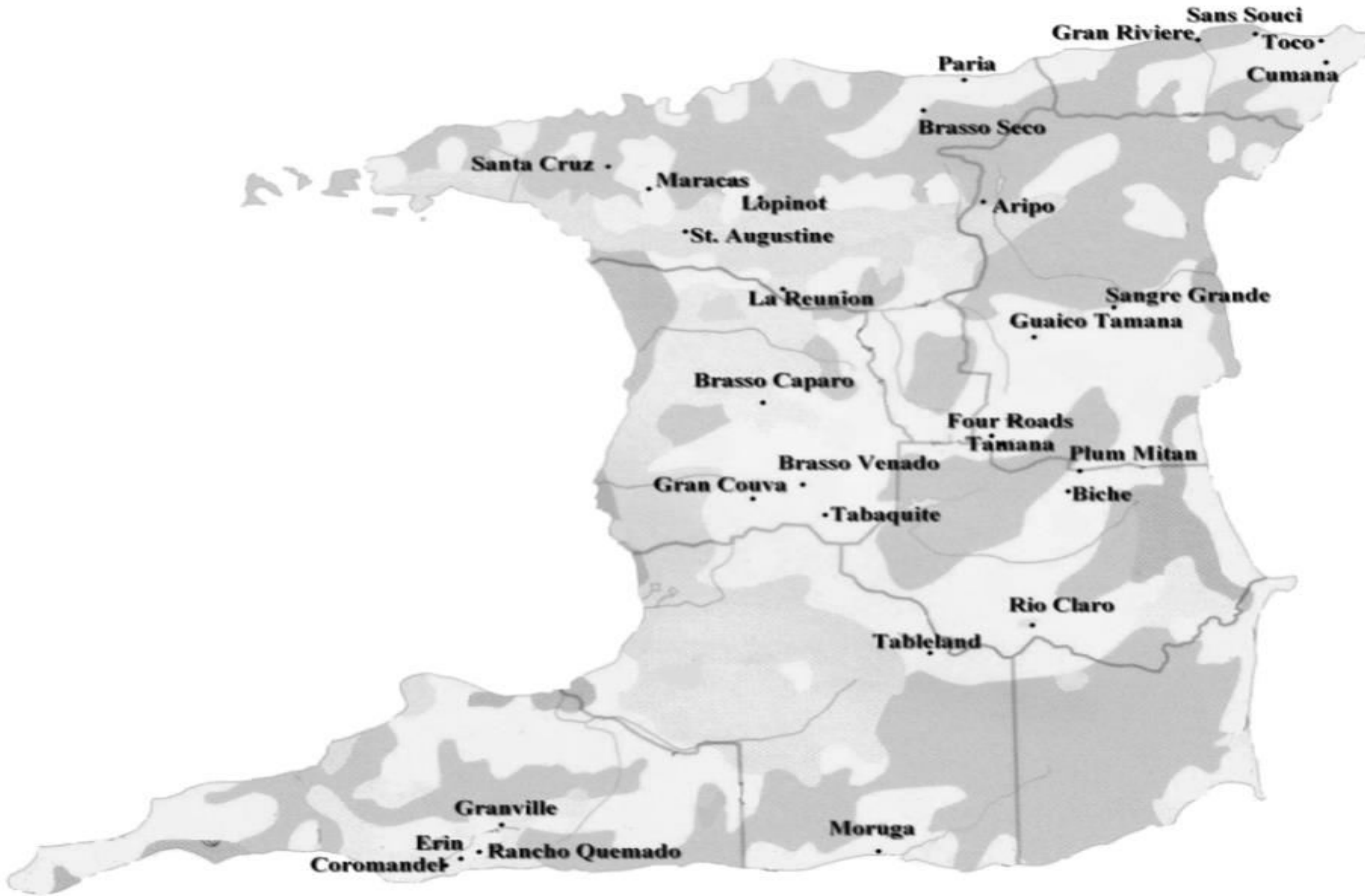
1. Evaluate the status of Cd in cocoa from all major cocoa-producing areas in Trinidad and Tobago.

2. Identify mechanisms and possible sources responsible for the Cd contamination of local cocoa beans.

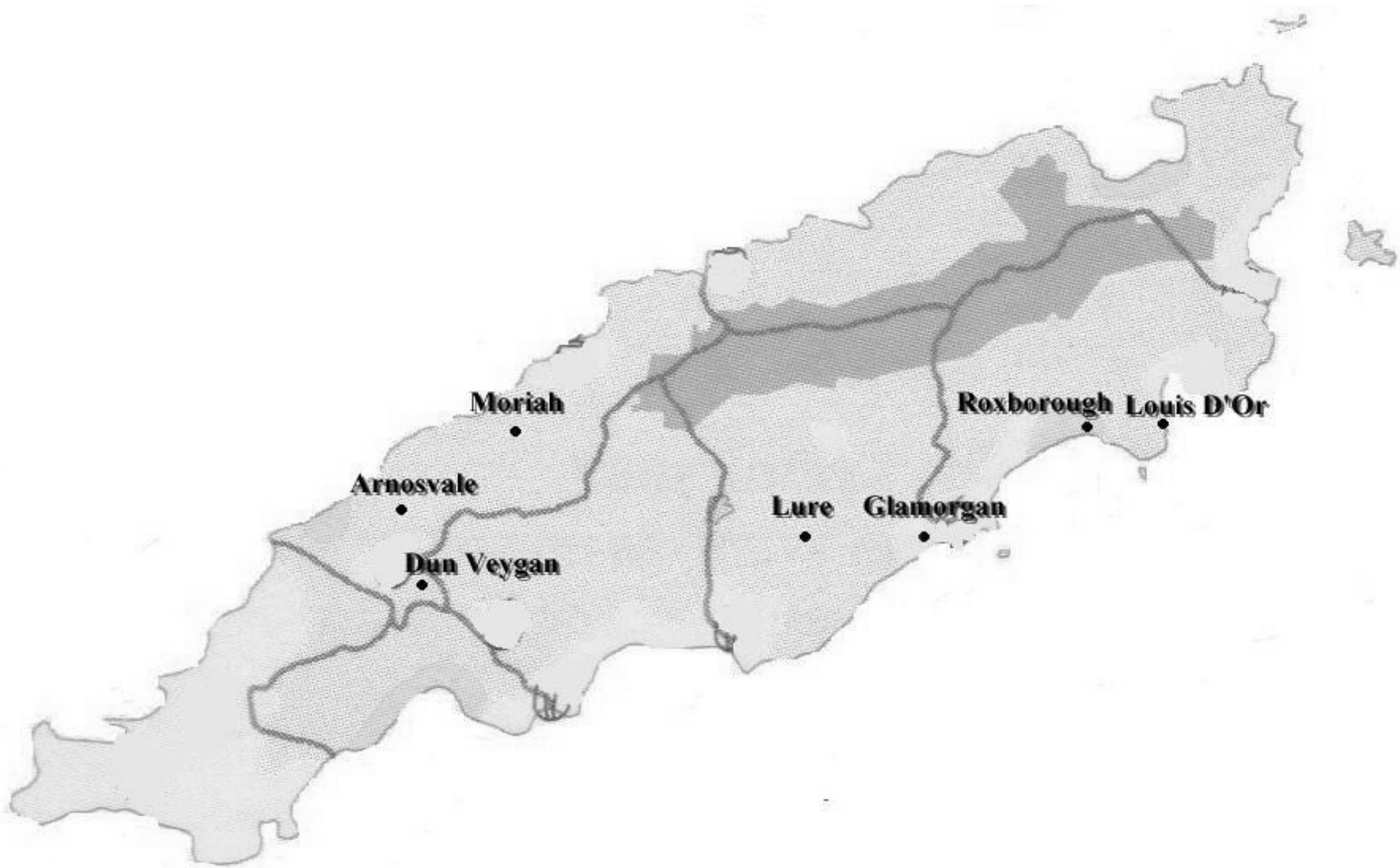
3. Evaluate and recommend measures to minimize Cd contamination of cocoa beans.

Evaluation of Cadmium Levels of Cocoa in T&T

Mapping of Cocoa Areas: Trinidad



Tobago


Moriah
Arnosvale
Dun Veygan
Lure
Glamorgan
Roxborough
Louis D'Or

Collection/Preparation/Analysis of Samples

1. Cocoa Pods

2. Processed beans

4. Soil Core

3. Leaves

Results

Concentrations of Cd determined

Detectable concentrations found in samples from some areas:

Leaves (0.54-5.21µg/g)

↓

Pods (0.53-4.49µg/g)

↓

Shells (0.44-4.41µg/g)

↓

Nibs (0.35-3.82µg/g)

↓

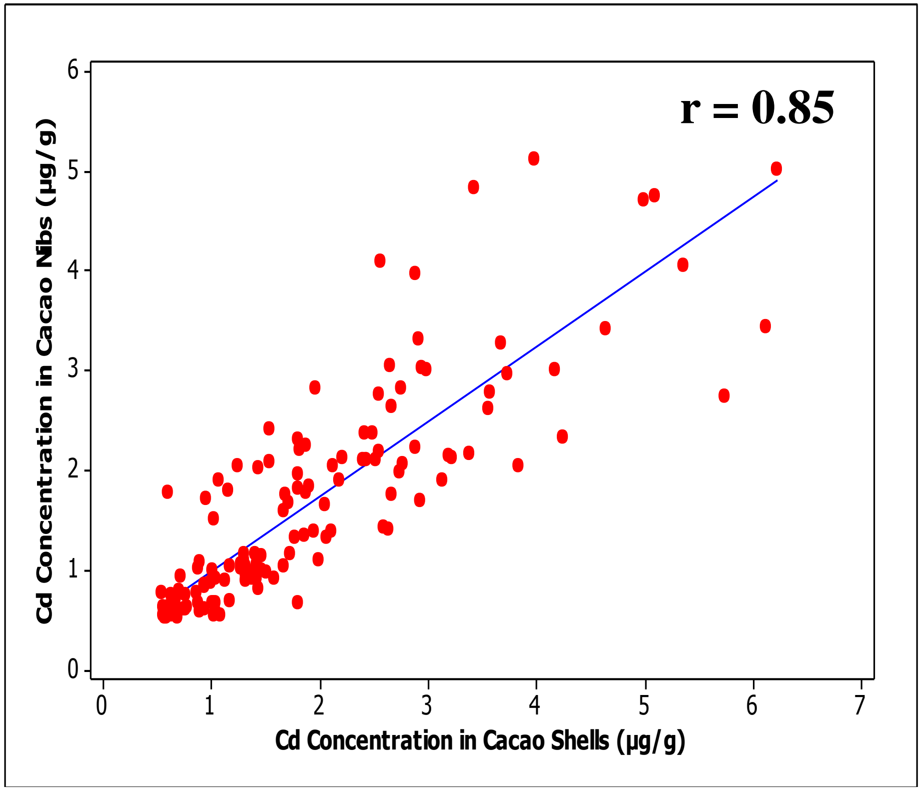
Soils (0.3-1.7µg/g)

Comparison with Cd Food Safety Standards

- **Nib** Cd levels would exceed proposed Maximum Permissible Limit(MPL) (0.8 mg/kg $\geq$ 50% Cocoa Solids) <u>for some areas.</u>

Significant Trend: Cd Distribution in Nibs & Shells

Scatter-plot of Cd conc. in Nibs vs. Cd conc. in Shells



Pearson correlation coefficient (r), Significant ($p<0.05$)

Implications:

1. EU and other regulatory bodies

Current system of analysis uses whole bean (Nib + Shell)

2. Chocolate manufacturers

Deliberately or inadvertently include shells in chocolate production

Mechanism and Possible Sources of Cd Contamination

Relationship between Cd levels in Cocoa Tissues Soil

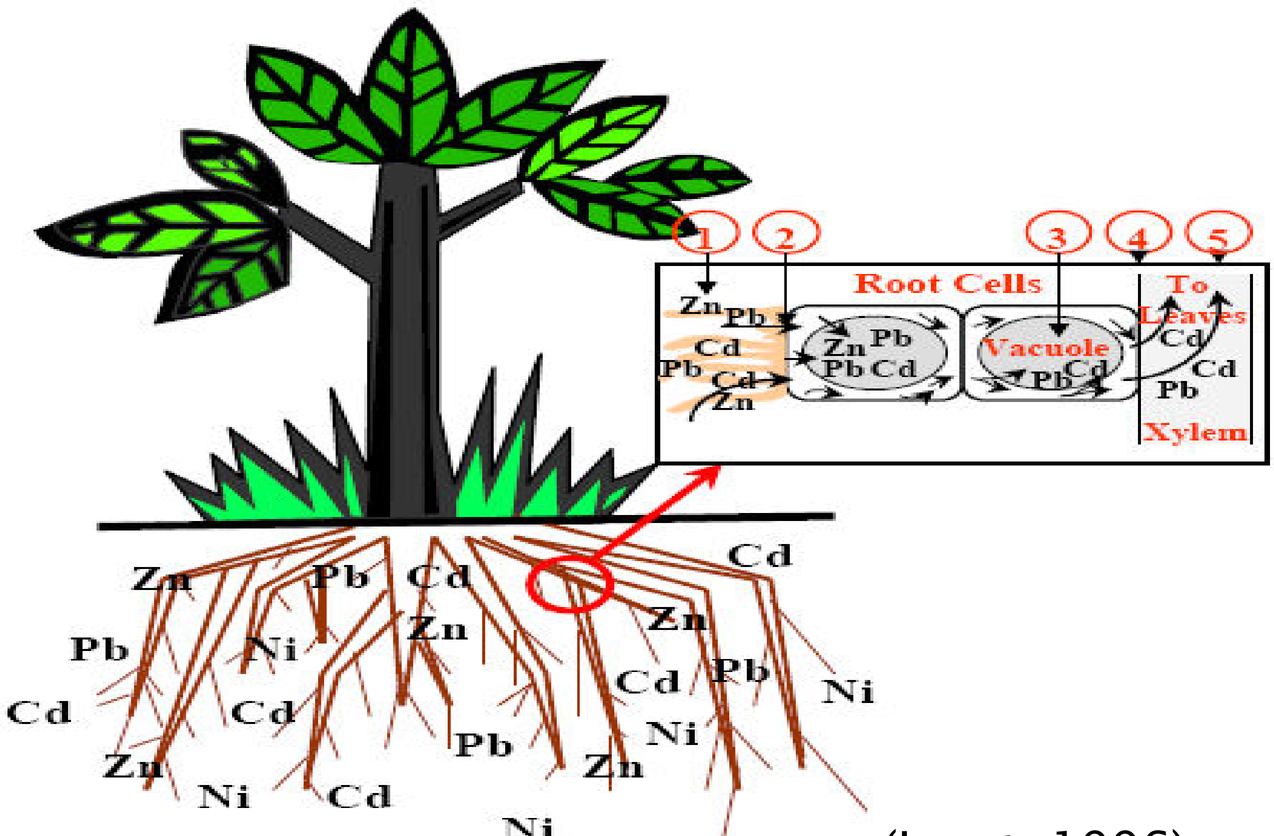
Pearson correlation coefficients (r) between Cd levels in cacao tissues/soil

Cacao Tissue	Correlation Soil (DTPA-Extractable)
Nib	(r = 0.848)
Shell	(r = 0.769)
Pod	(r = 0.637)
Leaf	(r = 0.752)

Significant ($p<0.05$)

Cd Absorption and Accumulation Mechanisms in Cacao

Root uptake (Primary route of uptake)



(Lasat, 1996)

Possible Sources of Soil Cd Contamination

Natural:

1. Soils of Volcanic Origin
2. Recycling of contaminated Leaf Litter

Anthropogenic:

1. Fertilizers
2. Pollutants from Flood-Prone Areas (Flooding/Irrigation)
3. Biosolids/Manures
4. Atmospheric deposition

Other Factors influencing Soil Cd Bioaccumulation

1. Soil type (Silt, Sandy, Clay, Loam, Organic)

2. Cation Exchange Capacity : defined as the degree to which a soil can adsorb and exchange cations.

3. Competing Trace Elements (Zn, Fe)

4. Soil pH

Evaluation of Measures to Minimize Cd Contamination to Cacao Soils

Mitigation Strategies

- Liming (Hydrated Lime)
  - Increase pH of soils
  - Immobilizes Cd
  - Minimizes uptake

- Mychorrizal Bio-fertilizers
  - Absorbs Cd
  - Potentially minimizes uptake

Evaluation of Lime Treatment (Field Application)

Methodology

- Cocoa plantation with significant levels of Cd in Trinidad identified and selected for study

  i. Lime requirement determined → Lime application

  ii. DTPA-Extractable Cd, pH & Cd in leaves were monitored monthly

Evaluation of Lime Treatment

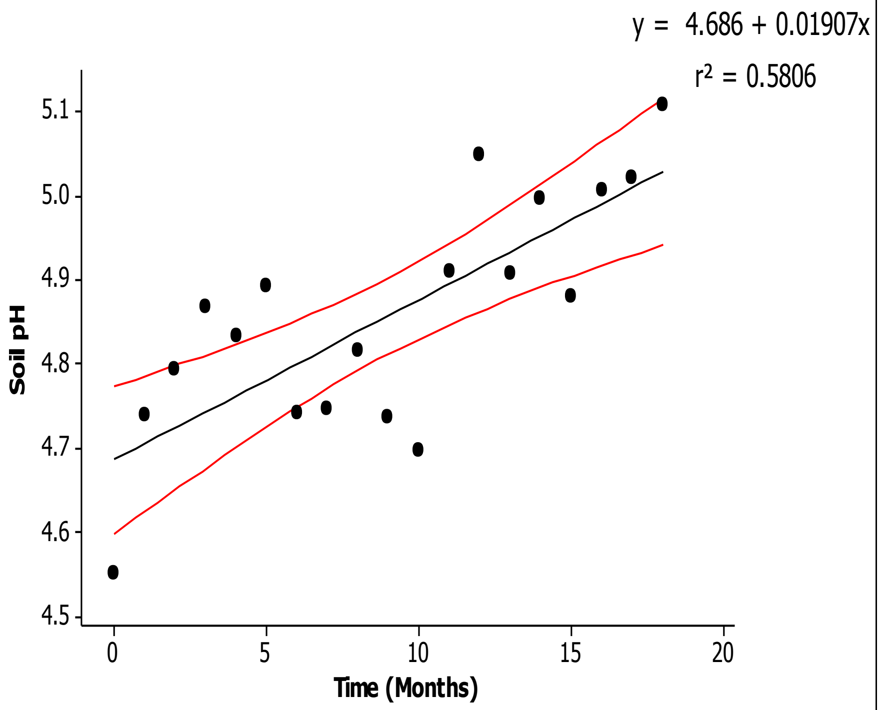


Figure 1(a): Soil pH for Lime-treated trees

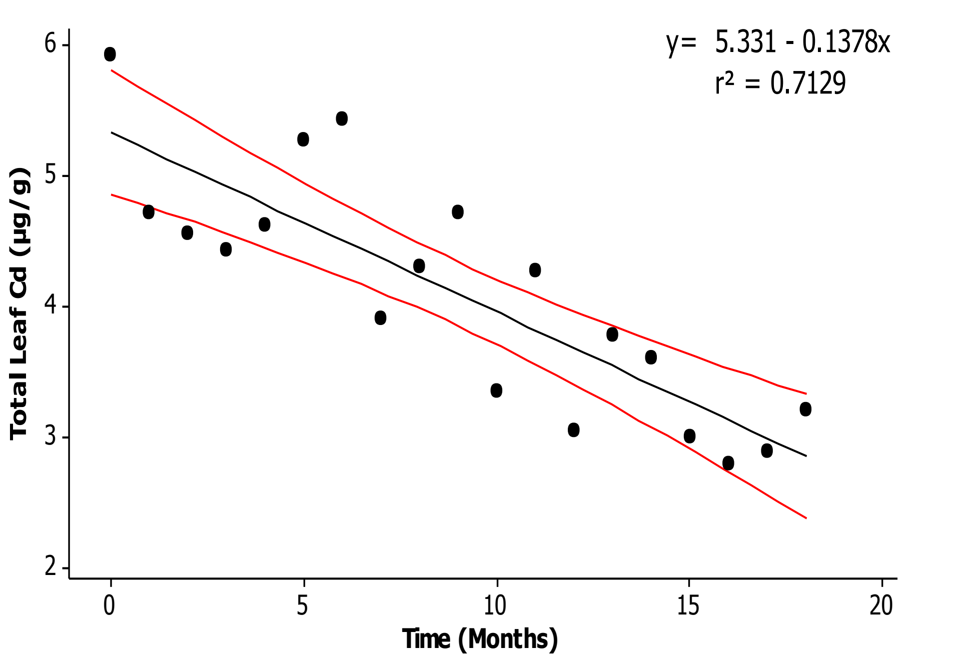


Figure 1(e): Total Leaf Cd for Lime-treated trees

Inoculation and Pot Trial Setup

Inoculation of cacao cutting

Randomized pot trial treatments

Cd Accumulation in Non-Mycorrhizal (A) vs Mycorrhizal (B) Treated Cacao Plants

Mean Leaf Cd/g of Plant for Treatments A and B over 4 Months

	Cd (µg/g)/g Leaves DW ± SD			
Month	1	2	3	4
Treatment				
A	0.86±0.13	5.45±0.62	12.15±0.65	13.16±1.20
B	1.43±0.32	8.92±1.49	15.40±0.82	16.41±1.72

Mean Stem Cd/g of Plant for Treatments A and B over 4 Months

	Cd (µg/g)/g Stem DW ± SD			
Month	1	2	3	4
Treatment				
A	2.06±0.39	6.73±0.19	9.36±0.54	7.37±0.56
B	3.77±0.86	12.29±0.25	12.30±2.34	9.57±0.41

Conclusions

- Status of Cd in cocoa beans established.
- The distribution of Cd levels in shells may have food safety implications.
- Possible sources of Cd contamination in cocoa identified.
- Lime treatment trends indicate promise for Cd reduction.
- Mycorrhizal bio-fertilizer treatment increased Cd uptake.

Acknowledgements

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Thank You!