



IMPROVING LIVES THROUGH  
AGRICULTURAL RESEARCH

HQ004/14

# R & D *in* AGRICULTURE



ISSUE 10  
December 2014

## A Bulletin on Information Resources



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*Improving Lives Through Agricultural Research*

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## ***R&D in Agriculture: a bulletin on information resources***

### **AIMS AND SCOPE**

The **R&D in Agriculture: a bulletin on information resources** aims to guide CARDI staff and other agricultural stakeholders in the Caribbean Community (CARICOM) and abroad to articles, journals, books, audio-visual materials, institutions and events on the following:

#### ***Commodities***

- Roots & tubers (cassava, sweet potatoes)
- Cereals & grain legumes
- Hot peppers
- Fruits & vegetables
- Small ruminants

#### ***Thematic Areas***

- Protected agriculture
- Emerging issues (agro-energy, herbals, organics)
- Soil & water management
- Risk management (climate change, invasive species)
- Germplasm
- Biotechnology
- Feeds and feeding systems

These are the priority commodities and thematic areas in the Medium-Term Plan (2011/2013) of the Caribbean Agricultural Research and Development Institute (CARDI). They were identified after consultation with our CARICOM member states and contribute to the implementation of the Jagdeo Initiative and the Regional Transformation Programme (RTP) for Agriculture.

Short bibliographic references to publications, brief descriptions of the research and services of relevant institutions, as well as lists of events are presented in this publication. Where possible a web address (URL) is provided so that readers may visit the webpage / website and access the full abstract, summary, document, or details for the acquisition of the resource.

Issues of this publication are available on our website, [www.cardi.org](http://www.cardi.org), under the Publications section.

***Frequency:*** 3 times a year - April, August, December

## TABLE OF CONTENTS

<b>COMMODITIES</b>	<b>3</b>
<b>Cereals &amp; Grain Legumes</b>	<b>3</b>
<b>Roots and Tubers - <i>Cassava, Sweet Potato</i></b>	<b>3</b>
<b>Hot Peppers</b>	<b>5</b>
<b>Fruits &amp; Vegetables – <i>Banana, Breadfruit, Tomatoes</i></b>	<b>6</b>
<b>Crops – Crop Protection</b>	<b>8</b>
<b>Livestock</b>	<b>9</b>
<b>GERMPLASM</b>	<b>10</b>
<b>THEMATIC AREAS</b>	
<b>Soil and Water Management</b>	<b>11</b>
<b>Natural Resource Management - <i>Climate Change</i></b>	<b>12</b>
<b>Herbals - <i>Ginger</i></b>	<b>14</b>
<b>OTHER AGRICULTURAL ASPECTS</b>	
<i>Agricultural Development</i>	<b>14</b>
<i>Agricultural Research</i>	<b>15</b>
<i>Food Security</i>	<b>15</b>
<i>Innovation</i>	<b>16</b>
<i>Value Chains</i>	<b>16</b>

## COMMODITIES: Cereals & Grain Legumes

### **Controlling Asian soybean rust (*Phakopsora pachyrhizi*) with *Bacillus* spp. and coffee oil**

Dalton Vinicio Dorighello, Wagner Bettiol, Nilson Borlina Maia, Regina Maria Vilas Bôas de Campos Leite

2015. Crop Protection 67:59-65

#### Abstract

Asian soybean rust is currently the main soybean disease in Brazil and its control is primarily accomplished with fungicides. This study evaluated the potential of *Bacillus* spp. and coffee oil, alone and combined with fungicide, to inhibit the germination of *Phakopsora pachyrhizi* uredospores and control the disease on detached leaves and plants in greenhouse and field conditions. The trials were carried out using the BRS 316 RR soybean cultivar. *Bacillus subtilis* (QST-713) and *Bacillus pumilus* (QST-2808) isolates, roasted and crude coffee oils used individually, as well as coffee oils combined with half dose of fungicide, inhibited uredospore germination by 100%. In tests with detached leaves, *B. subtilis* (isolates QST-713, AP-3, and AP-51) and *B. pumilus* (QST-2808) reduced disease severity by 98.6, 75.3, 61.2, and 97.7%, respectively. The reductions resulting from crude and roasted coffee oils were 80.1 and 87.7% compared to 77.5, and 84.4%, respectively, at concentrations of 2 and 1%. Under greenhouse conditions, all treatments, except *B. subtilis* AP-51, reduced the area under the disease progress curve (AUDPC), while under field conditions, the *B. subtilis* QST-713 isolate and roasted coffee oil at 1 and 2% reduced disease severity by 23, 18, and 23%, respectively. The results indicate that *B. subtilis*, *B. pumilus*, and coffee oils exhibit the potential to control Asian soybean rust disease.

**Keywords:** Biological control; Alternative control; Natural products; *Glycine max*

<http://www.sciencedirect.com/science/article/pii/S0261219414003007>

### **Grain legumes strategies and seed roadmaps for select countries in Sub-Saharan Africa and South Asia**

Monyo, E S and Gowda, C L L (eds.)

2014. Patancheru, Hyderabad, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. (Project Report)

<http://oar.icrisat.org/8016/>

### **Training Manual for Improving Grain Postharvest Handling and Storage.**

Prof Rick Hodges and Dr Tanya Stathers

2012. UK: World Food Programme and Natural Resources Institute, Natural Resources Institute, July 2012

<http://documents.wfp.org/stellent/groups/public/documents/reports/wfp250916.pdf>

## COMMODITIES: ROOTS & TUBERS

### **CASSAVA:**

#### **A milestone in the doubled haploid pathway of cassava**

P. I. P. Perera, C. A. Ordoñez, L. A. Becerra Lopez-Lavalle, B. Dedicova

2014. Protoplasma 251:233-246

#### Abstract

This study was aimed at inducing androgenesis in cultured anthers of cassava (*Manihot esculenta* Crantz) to develop a protocol for the production of doubled haploids. Microspore reprogramming was induced in cassava by cold or heat stress of anthers. Since the anthers contain both haploid microspores and diploid somatic cells, it was essential

to verify the origin of anther-derived calli. The origin of anther-derived calli was assessed by morphological screening followed by histological analysis and flow cytometry (FCM). Additionally, simple sequence repeat (SSR) and amplified fragment length polymorphism (AFLP) assays were used for the molecular identification of the microspore-derived calli. The study clearly demonstrated the feasibility of producing microspore-derived calli using heat- or cold-pretreated anthers. Histological studies revealed reprogramming of the developmental pathway of microspores by symmetrical division of the nucleus. Flow cytometry analysis revealed different ploidy level cell types including haploids, which confirmed their origin from the microspores. The SSR and AFLP marker assays independently confirmed the histological and FCM results of a haploid origin of the calli at the DNA level. The presence of multicellular microspores in the in vitro system indicated a switch of developmental program, which constitutes a crucial step in the design of protocols for the regeneration of microspore-derived embryos and plants. This is the first detailed report of calli, embryos, and abnormal shoots originated from the haploid cells in cassava, leading to the development of a protocol for the production of doubled haploid plants in cassava.

**Keywords:** Androgenesis; Amplified fragment length polymorphism (AFLP); Flow cytometry; Histology; Microspore reprogramming; Simple sequence repeat (SSR)

Open Access article available at [http://download.springer.com/static/pdf/556/art%253A10.1007%252Fs00709-013-0543-6.pdf?auth66=1411229894\\_1fa1aeb802226fa73e3fa95425f784b5&ext=.pdf](http://download.springer.com/static/pdf/556/art%253A10.1007%252Fs00709-013-0543-6.pdf?auth66=1411229894_1fa1aeb802226fa73e3fa95425f784b5&ext=.pdf)  
<http://link.springer.com/article/10.1007%2Fs00709-013-0543-6#page-1>

## **SWEET POTATO:**

### **Establishment of a grafted overhead-sweetpotato cultivation system with root-function spatial division**

Ming Li, Meifang Peng, Yufan Fu, Zhigang Pu, Wenfang Tan, Dayi Wang, Wenzhao Yan  
2014. *Scientia Horticulturae* 176: 303-310

#### Abstract

We report here a new cultivation system for sweetpotato [*Ipomoea batatas* (L.) Lam.] production, named grafted overhead-sweetpotato cultivation (GOSC) system. In this system, sweetpotato (as scions) was grafted with convolvulaceae relatives (as stocks), and the stems of grafted sweetpotato were buried in a solid medium without any nutrient and hung in the air to regenerate overhead-sweetpotato (storage roots). The results showed that *Ipomoea trifida* (6×), Beinong5521 (5×) and SH-2 (6×) were the best stocks. All the tested sweetpotato cultivars could produce overhead-sweetpotato with different yields. The mixture of sand, perlite and vermiculite with a 1:1:1 (v/v/v) ratio was the best solid medium for the GOSC system. The key stage of overhead-sweetpotato formation was about 20 days to 55 days after stem buried. Since storage roots are not regenerated from stocks grown in fertilized soil but from scion stems buried in non-fertilized solid medium, it seemed that the grafted overhead-sweetpotato plants had root-function spatial division (RFSD), i.e. absorbing roots of stocks and storage roots of scions. The graft compatibility with sweetpotato, the stock without underground storage roots, and the stem-buried media without nutrient supply, are the key factors for RFSD and overhead-sweetpotato production. This system could be used as a model for the study of the interaction between stock and scion as well as the source-sink relationship in sweetpotato.

**Keywords:** *Ipomoea batatas*; Grafted overhead-sweetpotato cultivation; Root-function spatial division; Convolvulaceae; Stock

<http://www.sciencedirect.com/science/article/pii/S0304423814004099>

### **Nitrogen mineralization and efficiency from co-applied animal manures and mineral fertilizer in sweetpotato under humid tropical conditions**

Paula Kaupa, B.K. Rajashekhar Rao  
2014. *Field Crops Research* 168: 48-56

#### Abstract

Frequently nitrogen (N) deficiency limits productivity in subsistence sweetpotato (*Ipomoea batatas* (L.) Lam.) production systems of humid tropical Papua New Guinea (PNG). It was envisaged to adopt a sub-optimal dose of 50 kg N ha<sup>-1</sup> through either locally available animal manures (poultry manure and goat manure) or mineral N fertilizer to improve immediate productivity of subsistence sweetpotato crop. The study involved an incubation

experiment to quantify N mineralization in relation to the crop response and efficiency of N fertilization options in field experiments. Co-application of mineral N fertilizer 25 kg N ha<sup>-1</sup> along with poultry manure 25 kg N ha<sup>-1</sup> produced the highest cumulative mineral N (20.8 mg N kg<sup>-1</sup>) in 90 days of incubation, followed closely by sole mineral N fertilizer 50 kg N ha<sup>-1</sup> and lowest mineral N (18.0 mg N kg<sup>-1</sup>) release was in sole application of goat manure 50 kg N ha<sup>-1</sup>. N mineralization data fitted well to parabolic model and revealed most increase in potentially mineralizable N pool ( $N_A$ ) in soils receiving co-application of mineral N and animal manures followed by mineral N 50 kg ha<sup>-1</sup> and least improvement was in sole animal manures application. Mineral N fertilizer 25 kg N ha<sup>-1</sup> plus poultry manure 25 kg N ha<sup>-1</sup> produced significantly ( $p < 0.05$ ) greater total tuber yields than control in 2011 and 2013 due to improved N uptake and N use efficiency. Present study, substantiates the appropriateness of promoting small dose of N at 50 kg N ha<sup>-1</sup> in the subsistence sweetpotato production systems of PNG. Co-application of animal manures 25 kg N ha<sup>-1</sup> with mineral N fertilizer 25 kg N ha<sup>-1</sup> assembles best option by improving potentially mineralizable N in the soil and enhancing efficiency of applied N.

**Keywords:** Co-application; Nitrogen mineralization; Sweetpotato; Humid tropics

<http://www.sciencedirect.com/science/article/pii/S0378429014002433>

## COMMODITIES: HOT PEPPERS

### **Mechanisms of salt tolerance in habanero pepper plants (*Capsicum chinense* Jacq.): Proline accumulation, ions dynamics and sodium root-shoot partition and compartmentation.**

Bojórquez-Quintal E, Velarde-Buendía A, Ku-González Á, Carillo-Pech M, Ortega-Camacho D, Echevarría-Machado I, Pottosin I and Martínez-Estévez M

2014. *Frontiers in Plant Science* Volume 5: Article 605. Published 12 November 2014. doi: 10.3389/fpls.2014.00605

#### Abstract

Despite its economic relevance, little is known about salt tolerance mechanisms in pepper plants. To address this question, we compared differences in responses to NaCl in two *Capsicum chinense* varieties: Rex (tolerant) and Chichen-Itza (sensitive). Under salt stress (150 mM NaCl over 7 days) roots of Rex variety accumulated 50 times more compatible solutes such as proline compared to Chichen-Itza. Mineral analysis indicated that Na<sup>+</sup> is restricted to roots by preventing its transport to leaves. Fluorescence analysis suggested an efficient Na<sup>+</sup> compartmentalization in vacuole-like structures and in small intracellular compartments in roots of Rex variety. At the same time, Na<sup>+</sup> in Chichen-Itza plants was compartmentalized in the apoplast, suggesting substantial Na<sup>+</sup> extrusion. Rex variety was found to retain more K<sup>+</sup> in its roots under salt stress according to a mineral analysis and microelectrode ion flux estimation (MIFE). Vanadate-sensitive H<sup>+</sup> efflux was higher in Chichen-Itza variety plants, suggesting a higher activity of the plasma membrane H<sup>+</sup>-ATPase, which fuels the extrusion of Na<sup>+</sup>, and, possibly, also the re-uptake of K<sup>+</sup>. Our results suggest a combination of stress tolerance mechanisms, in order to alleviate the salt-induced injury. Furthermore, Na<sup>+</sup> extrusion to apoplast does not appear to be an efficient strategy for salt tolerance in pepper plants.

<http://journal.frontiersin.org/Journal/10.3389/fpls.2014.00605/abstract>

**Open Access** <http://journal.frontiersin.org/Journal/10.3389/fpls.2014.00605/full>

### **Microsatellite based analysis of the genetic structure and diversity of *Capsicum chinense* in the Neotropics.**

Marissa Moses, Pathmanathan Umaharan, Selvadurai Dayanandan

2014. *Genetic Resources and Crop Evolution* 61: 741-755

#### Abstract

*Capsicum chinense* Jacq., one of the five domesticated species of pepper grown in the New World, is a major contributor to both local and international markets and the economy of the Caribbean islands. The planning and implementation of germplasm conservation and breeding programs for the sustainable use of *C. chinense* genetic resources are hampered by the poor understanding of the genetic structure and diversity of *C. chinense* in the region. In the present study, the genetic structure, diversity and relatedness of *C. chinense* germplasm collections within the

Caribbean basin and South America were assessed using nuclear microsatellite markers. *C. chinense* accessions (102) representing seven geographical regions were genotyped using nine polymorphic nuclear microsatellite markers along with 16 accessions representing four other species of *Capsicum*. The results revealed that the highest genetic diversity ( $He = 0.58$ ) was found in the Amazon region supporting the postulated center of diversity of *C. chinense* as the Amazon basin. The cluster analysis resulted in two distinct genetic clusters corresponding to Upper Amazon and Lower Amazon regions, suggesting two independent domestication events or two putative centers of diversity in these regions respectively. The cluster analysis further revealed that populations in Central America and the Caribbean may have been primarily derived from progenitors from Upper Amazon region and later diverged through geographical isolation. Conservation and germplasm collection programs should therefore target these genetically distinct clusters and satellite populations, towards supporting breeding programs to harness heterosis.

<http://link.springer.com/article/10.1007/s10722-013-0069-y>

## COMMODITIES: FRUITS & VEGETABLES

### BANANA:

#### A natural fungicide to combat Black Sigatoka

2014. SPORE - The magazine for agricultural and Rural Development in ACP countries, no.171, August - September 2014

[Full article](#)

Spraying of banana plantations with wild basil effectively combats Black Sigatoka

Black Sigatoka, or black leaf streak disease, caused by the fungus *Mycosphaerella fijiensis*, is a scourge for banana and plantain farmers in many developing countries as it causes severe yield losses. Instead of using chemical fungicides, an Ivorian team of researchers at Félix Houphouët Boigny University in Abidjan opted to test a natural fungicide, known as NECO. The main ingredient is an essential oil extract obtained from the freshly harvested leaves of *Ocimum gratissimum* (wild basil) by steam distillation. *O. gratissimum* is a very common plant in Côte d'Ivoire and is mainly used in the pharmaceutical sector.

The results of the study, conducted on two cultivars of plantain infected with *Mycosphaerella* between August 2010 and April 2011 in an experimental plot cultivated by the University, have shown that spraying the natural fungicide was an effective way to fight Black Sigatoka disease. The study was published in the Journal of Applied Biosciences, which can be downloaded: <http://tinyurl.com/mocd4jk>  
<http://spore.cta.int/en/component/content/article/292-spore/research-and-ict/10087-plantain>

#### Action du fongicide naturel NECO contre la *Mycosphaerella fijiensis* Morelet chez le bananier plantain (AAB) en Côte d'Ivoire

Kassi et al.

2014. Journal of Applied Biosciences 75:6183-6191. Abstract (English, French); Full Article (French)

[Abstract](#)

Objectives: The present study was to determinate effect of a natural fungicide coded NECO on *Mycosphaerella fijiensis* severity, fungi responsible of the black Sigatoka disease (BSD) on two cultivars of plantain (Corne 1 and Orishele) in natural infection condition.

Methodology and Results: NECO was obtained by extraction of essential oil from fresh leaves of *Ocimum gratissimum* and sprayed in a mixture with banole oil at 5 ml/l. The application of NECO on banana leaves was done at 2000 units corresponding of disease state development (DSD) of 10 plantain trees treated. 4 applications of NECO were done during the period of evaluation (November 2010 - April 2011). Weekly evaluation of some phytopathological descriptors (PJFT, PJFN, PJF3, EEM, IS) of BSD on field treated revealed lower levels of

infection by the black Sigatoka. Values of the EEM (DSD) were significantly reduced after each treatment, youngest leave touched by the disease (PJFT) is remained higher than those of untreated field, level of youngest leave necrosed (PJFN) was higher than 6 and index of disease severity (IS) was cancelled at the 16th week of observation. Conclusion and application of findings: Foliar spray with the NECO can be used as biological mean of fight against *Mycosphaerella fijiensis* and can be associated in an integrated system to fight against black Sigatoka disease in banana field.

**Keywords:** Plantain, *Mycosphaerella fijiensis*, NECO, Biological Control Control, Côte d'Ivoire  
<http://m.elewa.org/JABS/2014/75/4.pdf>

## **Mobilizing banana science for sustainable livelihoods, IHC 2014 - Australia | Promusa proceedings**

As part of the 29th International Horticultural Congress, ProMusa organized a symposium on the theme **Unravelling the banana's genomic potential**. In addition to the ProMusa symposium, this page also features presentations on bananas given in other symposia. IHC 2014 was held in Brisbane, Australia from 18 to 20 August 2014.

<http://www.promusa.org/article117>

The global spread of tropical race 4 and means to address its threat to banana production

Theme 1: Musa diversity and conservation

Theme 2: Musa host reaction to biotic and abiotic stress

Theme 3: Musa Crop Improvement For Host Reaction And Quality

Theme 4: New Cultivars For Farmers And Consumers (On-Farm Evaluation, Release And Adoption)

Theme 5: integrated crop management and value chains

Symposium poster presentations

Presentations on banana given in one of the other IHC symposia

Banana Streak Viruses and Their Impact on the Use of Germplasm

General Promusa Workshop

## **BREADFRUIT:**

### **Composition and growth of seedless breadfruit *Artocarpus altilis* naturalized in the Caribbean**

J. Nacitas Latchoumia, S. Adenet, G. Aurore, K. Rochefort, A. Buléon, L. Fährasmane  
2014. *Scientia Horticulturae* 175: 187–192

#### Abstract

The breadfruit (*Artocarpus altilis*), was domesticated in Oceania in ancient time, and was naturalized in the tropical Americas at the end of 18th century. It is today a Neglected and Under-utilized crop Species (NUS). This starchy fruit is used as a vegetable in traditional diet. A limited number of studies have examined breadfruit development and its nutritional value. To contribute to breadfruit processing development and thereby increase the globally available food biodiversity, breadfruit assessment has to be performed with modern tools. We studied morphology and analytical features of mature seedless breadfruit grown in Martinique (French West Indies) divided in for climatic areas, and in two seasons. The fruit content in starch, its pH, the pulp palatability, the fruit weight and the peel firmness were different on the season (temperature, rainfall). The growth curve of the fruit was sigmoid and 18 weeks long, with the fruit becoming mature and ready to crop in the 16th week of its development cycle.

**Keywords:** Breadfruit; Starch; Growth; Maturity; Composition

<http://www.sciencedirect.com/science/article/pii/S030442381400315X>



## TOMATOES:

### **Physiological responses to Megafol® treatments in tomato plants under drought stress: a phenomic and molecular approach**

Angelo Petrozza, Antonietta Santaniello, Stephan Summerer, Gianluca Di Tommaso, Donata Di Tommaso, Eleonora Paparelli, Alberto Piaggese, Pierdomenico Perata, Francesco Cellini  
2014. *Scientia Horticulturae* 174: 185–192

#### Abstract

Drought is one of the most significant abiotic stresses that limits the growth and productivity of crop plants. We investigated the physiological and molecular responses of tomato plants treated with Megafol® (Valagro S.p.A), under specific drought conditions. The goal was to evaluate the impact of Megafol®, a biostimulant composed of a complex of vitamins, aminoacids, proteins and betaines, in attenuating the negative physiological responses of drought. Tomato plants were grown in a greenhouse, and physiological parameters were collected using Scanalyzer 3D (LemnaTec, GmbH), a plant phenomics platform. Using this technology it is possible to dynamically study the effects of biostimulants, such as Megafol®, on plant development in terms of early detection of physiological plant stress responses. The results showed that drought-stressed plants treated with Megafol® were healthier in terms of the biomass produced and chlorophyll fluorescence, thus highlighting the higher tolerance to stress of the treated plants. The effects of Megafol® were also studied at a molecular level by analysing the induction of genes typically involved in drought stress responses. Our results demonstrate the efficacy of Megafol® to reduce drought-stress related damage in tomato plants.

**Keywords:** Drought stress; Biostimulants; Megafol; Tomato; Scanalyzer 3D

<http://www.sciencedirect.com/science/article/pii/S0304423814002891>

## COMMODITIES: CROPS – CROP PROTECTION

### **DIVECOSYS: Bringing together researchers to design ecologically-based pest management for small-scale farming systems in West Africa**

Thierry Brévault, Alain Renou, Jean-François Vayssières, Guillaume Amadji, Françoise Assogba-Komlan, Mariama Dalanda Diallo, Hubert De Bon, Karamoko Diarra, Abdoulaye Hamadoun, Joël Huat, Pascal Marnotte, Philippe Menozzi, Patrick Prudent, Jean-Yves Rey, Dieynaba Sall, Pierre Silvie, Serge Simon, Antonio Sinzogan, Valérie Soti, Manuele Tamò, Pascal Clouvel  
2014. *Crop Protection* 66: 53-60

#### Abstract

Crop pests are a major constraint to the intensification of agricultural production in the tropics, with novel issues related to global change (climate, land use, biological invasions, etc.), food security and preservation of natural resources and biodiversity. A research, extension and education network called DIVECOSYS (Diversity of cropping systems and ecologically-based pest management in West Africa) was launched in 2010 to synergize applied research actions in response to growing concerns on the vulnerability of agricultural systems to pest management in West Africa. This scientific network brings together research and academic institutions, with expertise spanning a multidisciplinary perspective from biology and ecology to remote sensing, agronomy and integrated pest management. Its main scientific objective is to explore the potential of biodiversity and ecological processes such as pest regulation, enabling novel ecologically-based models for productive systems, reduction of pesticide use, and adaptation or resilience of farming systems in the face of environmental disruptions. From Northern Senegal to Southern Benin, the research group explores a wide range of ecoregions and socio-ecological contexts, including stakeholders and their objectives, land use and agricultural practices, and management of biodiversity for enhancing biological control. Main challenges to be turned into opportunities include (i) encouraging collaborations amongst researchers from different scientific fields, (ii) fostering interactive research and synergies among research institutions and among countries, and (iii) developing an ecological engineering approach for the design of sustainable agricultural systems for smallholder farmers.

**Keywords:** Research network; Biodiversity; Biological control; Ecosystem services; Landscape; Africa

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<http://www.sciencedirect.com/science/article/pii/S0261219414002713>

## COMMODITIES: LIVESTOCK

### Climate change adaptation in mixed crop–livestock systems in developing countries

Philip K. Thornton, Mario Herrero

2014. *Global Food Security* 3:99–107

#### Abstract

Mixed crop–livestock systems produce most of the world's milk and ruminant meat, and are particularly important for the livelihoods and food security of poor people in developing countries. These systems will bear the brunt of helping to satisfy the burgeoning demand for food from increasing populations, particularly in sub-Saharan Africa and South Asia, where rural poverty and hunger are already concentrated. The potential impacts of changes in climate and climate variability on these mixed systems are not that well understood, particularly as regards how the food security of vulnerable households may be affected. There are many ways in which the mixed systems may be able to adapt to climate change in the future, including via increased efficiencies of production that sometimes provide important mitigation co-benefits as well. But effective adaptation will require an enabling policy, technical, infrastructural and informational environment, and the development challenge is daunting.

**Keywords:** Resilience; Diversification; Risk; Food security; Vulnerability; Co-benefits

<http://www.sciencedirect.com/science/article/pii/S2211912414000108>

### Industrial and Rural Activities in the Goat Sector including Science, Innovation and Development

2014. *Small Ruminant Research* 121: 1-160. Special Issue

<http://www.sciencedirect.com/science/journal/09214488/121/1>

#### Partial Contents

- Science, technology, innovation and governance for the goat sectors
- Zoonoses in goats: How to control them
- Assisted reproduction technologies in goats
- State-of-the-art of electronic identification techniques and applications in goats
- Improvements in goat milk quality: A review
- Scaling up successful practices for pro-poor development projects involving goats: First outputs of a comparative study
- Chevron quality enhancement: Trends in pre- and post-slaughter techniques

### Small Ruminant Resource Manual

ATTRA, The National Sustainable Agriculture Information Service, USA. ATTRA is a program developed and managed by the National Center for Appropriate Technology (NCAT).

2010. National Center for Appropriate Technology (NCAT). 978p.

<http://www.iga-goatworld.com/blog/small-ruminant-toolbox-resource-manual>

This Small Ruminant Toolbox was developed by the National Center for Appropriate Technology (NCAT) in order to provide a collection of information for small ruminant producers and educators. The Small Ruminant Toolbox includes many publications, presentations and other resources that will be helpful to small ruminant producers.

You can download the Toolbox from Sustainable Agriculture Research & Education. Or download the *Small Ruminant Resource Manual*. Sections include: Whole Farm Planning; Assessment of Plant and Soil Resources; Animal Resources; Forage Utilization; Health; Facilities; Marketing/Economics; Organic Production

## State-of-the-art on use of insects as animal feed

Harinder P.S. Makkar, Gilles Tran, Valérie Heuzé, Philippe Ankers

2014. *Animal Feed Science and Technology* 197: 1–33

### Abstract

A 60–70% increase in consumption of animal products is expected by 2050. This increase in the consumption will demand enormous resources, the feed being the most challenging because of the limited availability of natural resources, ongoing climatic changes and food–feed–fuel competition. The costs of conventional feed resources such as soymeal and fishmeal are very high and moreover their availability in the future will be limited. Insect rearing could be a part of the solutions. Although some studies have been conducted on evaluation of insects, insect larvae or insect meals as an ingredient in the diets of some animal species, this field is in infancy. Here we collate, synthesize and discuss the available information on five major insect species studied with respect to evaluation of their products as animal feed. The nutritional quality of black soldier fly larvae, the house fly maggots, mealworm, locusts–grasshoppers–crickets, and silkworm meal and their use as a replacement of soymeal and fishmeal in the diets of poultry, pigs, fish species and ruminants are discussed. The crude protein contents of these alternate resources are high: 42–63% and so are the lipid contents (up to 36% oil), which could possibly be extracted and used for various applications including biodiesel production. Unsaturated fatty acid concentrations are high in housefly maggot meal, mealworm and house cricket (60–70%), while their concentrations in black soldier fly larvae are lowest (19–37%). The studies have confirmed that palatability of these alternate feeds to animals is good and they can replace 25–100% of soymeal or fishmeal depending on the animal species. Except silkworm meal other insect meals are deficient in methionine and lysine and their supplementation in the diet can enhance both the performance of the animals and the soymeal and fishmeal replacement rates. Most insect meals are deficient in Ca and its supplementation in the diet is also required, especially for growing animals and laying hens. The levels of Ca and fatty acids in insect meals can be enhanced by manipulation of the substrate on which insects are reared. The paper also presents future areas of research. The information synthesized is expected to open new avenues for a large scale use of insect products as animal feed.

**Keywords:** Insect meals; Insect larvae; Livestock; Monogastrics; Ruminants; Aquaculture

<http://www.sciencedirect.com/science/article/pii/S0377840114002326>

## Use of cassava in livestock and aquaculture feeding programs

Lukuyu, B., Okike, I., Duncan, A.J., Beveridge, M. and Blummel, M.

2014. Nairobi, Kenya: International Livestock Research Institute (ILRI). ILRI Discussion Paper 25

<https://cgspace.cgiar.org/bitstream/handle/10568/41924/DiscussionPaper25.pdf?sequence=4>

# GERMPLASM

## Genomics strategies for germplasm characterization and the development of climate resilient crops

Henry R J

2014. *Frontiers in Plant Science*. 5:68. doi: 10.3389/fpls.2014.00068

### Introduction

Food security requires the development and deployment of crop varieties resilient to climate variation and change. The study of variations in the genome of wild plant populations can be used to guide crop improvement. Genome variation found in wild crop relatives may be directly relevant to the breeding of environmentally adapted and climate resilient crops. Analysis of the genomes of populations growing in contrasting environments will reveal the genes subject to natural selection in adaptation to climate variations. Whole genome sequencing of these populations should define the numbers and types of genes associated with climate adaptation. This strategy is facilitated by recent advances in sequencing technologies. Wild relatives of rice and barley have been used to assess these approaches. This strategy is most easily applied to species for which a high quality reference genome sequence is

available and where populations of wild relatives can be found growing in diverse environments or across environmental gradients.

**Keywords:** genomics, evolution, climate adaptation, crops, wild crop relatives

<http://journal.frontiersin.org/Journal/10.3389/fpls.2014.00068/full>

## THEMATIC AREAS: SOIL AND WATER MANAGEMENT

### **Climate-smart tank irrigation: A multi-year analysis of improved conjunctive water use under high rainfall variability**

C. Siderius, H. Boonstra, V. Munaswamy, C. Ramana, P. Kabat, E. van Ierland, P. Hellegers

2015. *Agricultural Water Management* 148: 52-62

#### Abstract

Although water harvesting is receiving renewed attention as a strategy to cope with increasing seasonal and inter-annual rainfall variability, many centuries-old local water-harvesting reservoirs (tanks) in India are rapidly deteriorating. Easy access to groundwater is seen as one of the major threats to their maintenance and functioning. Potentially, however, conjunctive use of water from rain, tanks and groundwater reserves, supported by proper monitoring, could improve the resilience and productivity of traditional tank irrigation systems. To date, few quantitative multi-annual analyses of such climate-smart systems have been published. To redress this, we assess the sustainability of a rehabilitated tank irrigation system, by monitoring all inputs and outputs over a period of six years (12 cropping seasons). Our results show that during the period considered, improved conjunctive use resulted in a more stable cropping intensity, increased economic water productivity and higher net agricultural income. Groundwater tables were not negatively affected. We argue that improved conjunctive use can considerably reduce the vulnerability of tank irrigation to rainfall variability and thus is a valuable strategy in light of future climate change.

**Keywords:** Water harvesting; Tank rehabilitation; Groundwater; Conjunctive use; Water productivity; India

<http://www.sciencedirect.com/science/article/pii/S0378377414002807>

### **Control of waterborne microbes in irrigation: a review**

Rosa E. Raudales, Jennifer L. Parke, Charles L. Guy, Paul R. Fisher

2014. *Agricultural Water Management* 143:9-28

#### Abstract

A wide range of plant pathogens have been identified in irrigation water sources and distribution systems. Algae and equipment-clogging biofilms also result from high microbial levels in irrigation water. The literature was reviewed on the effectiveness of water treatment options to control waterborne microbes. Water treatments included chemicals (chlorine, bromine, chlorine dioxide, ionized copper, copper salts, ionized silver, ozone, hydrogen peroxide, and peroxyacetic acid), non-chemical or physical treatments (filtration, heat, and ultraviolet radiation) and ecological alternatives (constructed wetlands, biosurfactants, and slow sand filtration). The objective was to summarize the effective dose for controlling target waterborne microorganisms. The effective dose for chemical water treatments to control plant pathogens was in some cases above documented phytotoxicity thresholds, and for most crops and technologies the phytotoxicity thresholds remain unknown. Most efficacy research has been conducted on chlorine (20 articles) or copper (18), but only 0–7 articles were found on other water treatments currently in use, indicating major knowledge gaps in treatment efficacy. Research is needed on control methods for algae and biofilms, *in vivo* pathogen studies, phytotoxicity thresholds, and the relationship between pathogen inoculum level and disease incidence in irrigation water. Finally, improved overall system design is required for risk management of waterborne microbes in irrigation, including a multiple barrier approach incorporating pre-filtration, multiple treatment stages, and monitoring of water quality.

**Keywords:** Algae; Biofilm; Chlorination; Plant pathogens; Sanitation; Water treatment

<http://www.sciencedirect.com/science/article/pii/S0378377414001838>

## **Sequestering carbon and improving soil fertility; Validation of an improved method for estimating CO<sub>2</sub> flux**

Renaldo Belfon, Isaac Bekele, Gaius Eudoxie, Paul Voroney, Gregory Gouveia  
2014. *Geoderma* 235–236:323-328

### Abstract

Carbon dioxide flux to the atmosphere is the major pathway whereby carbon is lost from agricultural soils. Linear interpolation has traditionally been used to estimate soil CO<sub>2</sub> flux in lab-based studies but the resulting curves are not representative of biological systems. The objective of this study was to examine the effectiveness of linear, natural cubic spline and constrained cubic spline interpolation models for estimating CO<sub>2</sub> flux from contrasting soils under different management regimes. Cross-validation techniques were employed to examine the predictive accuracy, overshoot/undershoot behavior, smoothness and deviation of cumulative CO<sub>2</sub> flux estimates of each approach. The predictive accuracy of the interpolation models differed with soil type and between amended and unamended soils. Predictive accuracy also decreased with increased interval length though being sensitive to the nature of the region being estimated. Linear interpolation accurately predicted most measured data points and had a low spread of potential cumulative CO<sub>2</sub> flux values (between 154% and – 54%) but produced non-smooth curves. Natural cubic spline interpolation produced relatively smooth curves but had low predictive accuracy and high variability in potential cumulative CO<sub>2</sub> flux values (between 528% and – 617%). Constrained cubic spline interpolation produced the smoothest curves while its predictive accuracy and spread of potential cumulative CO<sub>2</sub> flux (between 175% and – 53%) was comparable to that of linear interpolation. These results demonstrate that the constrained cubic spline interpolation technique offers improvements over linear interpolation for estimating soil CO<sub>2</sub> flux.

**Keywords:** Climate change; Tropical soils; Carbon dynamics; Interpolation; Cross validation

<http://www.sciencedirect.com/science/article/pii/S0016706114002985>

## **THEMATIC AREAS: NATURAL RESOURCE MANAGEMENT**

### **CLIMATE CHANGE:**

#### **Climate-smart agriculture global research agenda: scientific basis for action**

Steenwerth, KL, Hodson, AK, Bloom, AJ, Carter, MR, Cattaneo, A, Chartres, CJ, Hatfield, JL, Henry, K, Hopmans, JW, Horwath, WR, Jenkins, BM, Kebreab, E, Leemans, R, Lipper, L, Lubell, MN, Msangi, S, Prabhu, R, Reynolds, MP, Solis, SS, Sischo, WM, Springborn, M, Tittonell, P, Wheeler, SM, Vermeulen, SJ, Wollenberg, EK, Jarvis, LS, Jackson, LE.

2014. *Agriculture and Food Security* 3:11 DOI: 10.1186/2048-7010-3-11

### Abstract

#### *Background*

Climate-smart agriculture (CSA) addresses the challenge of meeting the growing demand for food, fibre and fuel, despite the changing climate and fewer opportunities for agricultural expansion on additional lands. CSA focuses on contributing to economic development, poverty reduction and food security; maintaining and enhancing the productivity and resilience of natural and agricultural ecosystem functions, thus building natural capital; and reducing trade-offs involved in meeting these goals. Current gaps in knowledge, work within CSA, and agendas for interdisciplinary research and science-based actions identified at the 2013 Global Science Conference on Climate-Smart Agriculture (Davis, CA, USA) are described here within three themes: (1) farm and food systems, (2) landscape and regional issues and (3) institutional and policy aspects. The first two themes comprise crop physiology and genetics, mitigation and adaptation for livestock and agriculture, barriers to adoption of CSA practices, climate risk management and energy and biofuels (theme 1); and modelling adaptation and uncertainty, achieving multifunctionality, food and fishery systems, forest biodiversity and ecosystem services, rural migration from climate change and metrics (theme 2). Theme 3 comprises designing research that bridges disciplines, integrating stakeholder input to directly link science, action and governance.

### *Outcomes*

In addition to interdisciplinary research among these themes, imperatives include developing (1) models that include adaptation and transformation at either the farm or landscape level; (2) capacity approaches to examine multifunctional solutions for agronomic, ecological and socioeconomic challenges; (3) scenarios that are validated by direct evidence and metrics to support behaviours that foster resilience and natural capital; (4) reductions in the risk that can present formidable barriers for farmers during adoption of new technology and practices; and (5) an understanding of how climate affects the rural labour force, land tenure and cultural integrity, and thus the stability of food production. Effective work in CSA will involve stakeholders, address governance issues, examine uncertainties, incorporate social benefits with technological change, and establish climate finance within a green development framework. Here, the socioecological approach is intended to reduce development controversies associated with CSA and to identify technologies, policies and approaches leading to sustainable food production and consumption patterns in a changing climate.

*Open Access article at*

<http://www.agricultureandfoodsecurity.com/content/3/1/11>

<http://www.agricultureandfoodsecurity.com/content/pdf/2048-7010-3-11.pdf>

### **Importance of food-demand management for climate mitigation**

Bojana Bajželj, Keith S. Richards, Julian M. Allwood, Pete Smith, John S. Dennis, Elizabeth Curmi & Christopher A. Gilligan

2014. *Nature Climate Change* 4: 924–929

#### **Abstract**

Recent studies show that current trends in yield improvement will not be sufficient to meet projected global food demand in 2050, and suggest that a further expansion of agricultural area will be required. However, agriculture is the main driver of losses of biodiversity and a major contributor to climate change and pollution, and so further expansion is undesirable. The usual proposed alternative—intensification with increased resource use—also has negative effects. It is therefore imperative to find ways to achieve global food security without expanding crop or pastureland and without increasing greenhouse gas emissions. Some authors have emphasized a role for sustainable intensification in closing global ‘yield gaps’ between the currently realized and potentially achievable yields. However, in this paper we use a transparent, data-driven model, to show that even if yield gaps are closed, the projected demand will drive further agricultural expansion. There are, however, options for reduction on the demand side that are rarely considered. In the second part of this paper we quantify the potential for demand-side mitigation options, and show that improved diets and decreases in food waste are essential to deliver emissions reductions, and to provide global food security in 2050.

<http://www.nature.com/nclimate/journal/vaop/ncurrent/full/nclimate2353.html>

### **International Food Policy Research Institute (IFPRI) Climate Change website**

Highlights of IFPRI’s climate change related research and outputs

<http://climatechange.ifpri.info/>

### **Greenhouse gas emissions and fossil energy demand from small ruminant supply chains: Guidelines for quantification [Draft for Public Review]**

Livestock Environmental Assessment and Performance Partnership (LEAP)

2014. FAO

[http://www.fao.org/fileadmin/user\\_upload/benchmarking/docs/LEAP\\_Small\\_Ruminants\\_DRAFT.pdf](http://www.fao.org/fileadmin/user_upload/benchmarking/docs/LEAP_Small_Ruminants_DRAFT.pdf)

## THEMATIC AREAS: Herbs

### **Pythium soft rot of ginger: Detection and identification of the causal pathogens, and their control**

Duy Phu Le, Mike Smith, George William Hudler, Elizabeth Aitken

2014. Crop Protection 65: 153-167

#### Abstract

Ginger is considered by many people to be the outstanding member among 1400 other species in the family Zingiberaceae. Not only it is a valuable spice used by cooks throughout the world to impart unique flavour to their dishes but it also has a long track record in some Chinese and Indian cultures for treating common human ailments such as colds and headaches. Ginger has recently attracted considerable attention for its anti-inflammatory, antibacterial and antifungal properties. However, ginger as a crop is also susceptible to at least 24 different plant pathogens, including viruses, bacteria, fungi and nematodes. Of these, *Pythium* spp. (within the kingdom Stramenopila, phylum Oomycota) are of most concern because various species can cause rotting and yield loss on ginger at any of the growth stages including during postharvest storage. *Pythium gracile* was the first species in the genus to be reported as a ginger pathogen, causing Pythium soft rot disease in India in 1907. Thereafter, numerous other *Pythium* spp. have been recorded from ginger growing regions throughout the world. Today, 15 *Pythium* species have been implicated as pathogens of the soft rot disease. Because accurate identification of a pathogen is the cornerstone of effective disease management programs, this review will focus on how to detect, identify and control *Pythium* spp. in general, with special emphasis on *Pythium* spp. associated with soft rot on ginger.

**Keywords:** Oomycota; Pythium; Ginger; Advanced detection; Control strategies; Production

<http://www.sciencedirect.com/science/article/pii/S0261219414002415>

## OTHER AGRICULTURAL ASPECTS

### AGRICULTURAL DEVELOPMENT:

#### **33rd FAO Regional Conference for Latin America and the Caribbean, Santiago, Chile, 6- 9 May 2014**

Proceedings of the **33rd FAO Regional Conference for Latin America and the Caribbean, Santiago, Chile, 6- 9 May 2014** are available at <http://www.fao.org/about/meetings/larc33/en/>

- Report on 33rd FAO Regional Conference for Latin America and the Caribbean, Santiago, Chile, 6- 9 May 2014 <http://www.fao.org/docrep/meeting/030/mk390e.pdf>
- Full List of Documents <http://www.fao.org/unfao/govbodies/meeting-docs/rc/larc-33/en/>
- Priorities for FAO Activities in the Region 2014-17 <http://www.fao.org/docrep/meeting/030/mk075e.pdf>

#### **The State of Food and Agriculture 2014: Innovation in family farming**

2014. Rome: FAO

<http://www.fao.org/publications/sofa/en/>

<http://www.fao.org/3/a-i4040e.pdf>

Analyses family farms and the role of innovation in ensuring global food security, poverty reduction and environmental sustainability. It argues that family farms must be supported to innovate in ways that promote sustainable intensification of production and improvements in rural livelihoods. Innovation is a process through which farmers improve their production and farm management practices.

## AGRICULTURAL RESEARCH:

### **Agricultural sciences in transition from 1800 to 2020: Exploring knowledge and creating impact**

Huub Spiertz [Centre for Crop Systems Analysis (CSA), Plant Sciences Group, Wageningen University, P.O. Box 430, 6700 AK Wageningen, The Netherlands. Emeritus-professor Crop Ecology]

2014. European Journal of Agronomy 59: 96-106

#### Abstract

Transitions in agricultural sciences are brought about by incorporating new findings and insights emerging from biological, chemical and biophysical sciences, by more advanced ways of experimentation and last but not least by quantitative methods and models for data analyses and processing. Major breakthroughs occurred from 1800 onwards when new insights on photosynthesis and mineral nutrition were incorporated in the theory on the growth of crops. It took almost half a century before the humus theory was replaced by a more sound theory on mineral nutrition. The publication by Darwin on domestication in 1868 and the rediscovery of Mendel's laws in 1900 gave a boost to genetics underlying classical plant and animal breeding, which was mainly based on crossing and selection. A major accomplishment of the evolutionary synthesis was the compatibility of Mendelian inheritance with Darwinian natural selection. The discovery of the DNA-structure in the mid-fifties of the 20th century on modern plant breeding showed already impact within some decades. To assess the wide diversity of plant traits for the performance of plants in yield and quality of the produce advanced phenotyping method under controlled conditions has become popular. Genome-wide selection for environments with multiple stresses, however, does require phenotyping in situ. Since 1800 the transition from observations on the plant, field and farm towards dedicated experimentation took place. During the 19th and 20th century the methods for experimentation and data analyses were strongly improved. It took until the mid-20th century before the importance of experiments under controlled conditions was recognized. Studies of plant processes under controlled conditions provided the building blocks for mechanistic modelling of crop growth and production. A systems approach combining knowledge at different scales and incorporating cutting-edge findings from the basic sciences into applied sciences will become important for making a great leap forward in developing agricultural science with impact. Transitions in agricultural research will continue to depend on progress made in the related basic sciences and the capacity for agricultural research and innovation. Therefore, an adequate public funding is required to maintain or even accelerate progress in sciences. This requires the support of the public at large. Public-private partnerships will be needed to bridge the gap between science and innovation.

**Keywords:** Agronomy; Crop physiology; Plant breeding; Climate change; Cropping system; Resource use; Technology; Innovation

<http://www.sciencedirect.com/science/article/pii/S116103011400080X>

## FOOD SECURITY:

### **The system of crop intensification: Agroecological innovations for improving agricultural production, food security, and resilience to climate change**

SRI International Network and Resources Center (SRI-Rice)

2014. SRI-Rice / CTA

[http://publications.cta.int/media/publications/downloads/1795\\_pdf.pdf](http://publications.cta.int/media/publications/downloads/1795_pdf.pdf)

This publication reports on current 'work in progress' to raise agricultural productivity in eco-friendly ways in a number of countries around the world.

#### Contents

1. The need for sustainable intensification of agriculture
2. Agroecological management
3. Applications of agroecological strategies to other crops
4. Crop adaptations and results from farmers' fields
5. Planting with space
6. Wider applications and adaptations of SCI
7. Further extensions of agroecological management



- 8. Applications of agroecological thinking and practice
- 9. Conclusions

## INNOVATION:

### **NetGrow - Enhancing the innovativeness of food SMEs**

NetGrow, a European FP7 project with a duration of 4 years, started the first of May 2010 and aims at enhancing the innovativeness of food SMEs through an improved management of network learning and strategic network behaviour. NetGrow bundles the capacities of research institutions and SME organizations from 9 different countries [Belgium, Ireland, Netherlands, Hungary, Sweden, Denmark, Italy, France and Germany]. NetGrow invites SMEs from all over Europe to take part in the development of an innovation toolbox that will be designed according to the company needs.

- **NetGrow Toolbox for Innovation Networks. The EU NetGrow project to support “smart networking” by food SMEs.** TRResearch Summer 2014, pp.10-11  
[http://www.teagasc.ie/publications/2014/3239/TRResearch\\_Summer2014.pdf](http://www.teagasc.ie/publications/2014/3239/TRResearch_Summer2014.pdf)
- **NetGrow Newsletter • Issue 06 • April 2014**  
<http://teagasc-netgrow.cmail1.com/t/ViewEmail/y/74FC884EAFDB035C/650A1EB639D645339E794568BD214575>
- **NetGrow Library - latest NetGrow publications** <http://www.netgrow.eu/index.php?hova=18>
- **Netgrow website** <http://www.netgrow.eu/>

## VALUE CHAINS

### **Regional synthesis of ICT uptake and usage in agricultural value chains in the Caribbean. A component of the CTA/CARDI project: Strengthening ICTs in value chains in the Caribbean – study and promotion**

INFOCOMM Technologies (ICT) Ltd.

2014. St Augustine, Trinidad and Tobago: Caribbean Agricultural Research and Development Institute

The Caribbean Agricultural Research and Development Institute (CARDI) with support from the Technical Centre for Agricultural and Rural Cooperation (CTA) commissioned a Trinidad-based consulting firm (Infocomm Technologies Ltd.) to conduct a regional study on ICT usage in Caribbean agriculture value chains, with a specific focus on the value chains associated with domestically produced root crops and small ruminants (sweet potato and cassava and sheep and goats, respectively). The targeted value chains were: (1) fresh use and primary processing enterprises for cassava and sweet potato and;(2) meat (lamb, mutton and chevron) for sheep and goats. The use of ICT in the broader agricultural value chains, irrespective of commodities, was also investigated. This study was part of a larger CTA/CARDI project that aimed to strengthen agricultural value chains through increased ICT integration within the agricultural sectors of the region.

The study focused in particular on the discovery of the actors and associated ICT usage within the targeted value chains in each of the five focal countries (Barbados, Guyana, Jamaica, St Kitts and Nevis and Trinidad and Tobago). In addition to a comprehensive review of available documentation, the team met with actors along these two targeted value chains. The categories of respondents interviewed were input suppliers (40%), producers (31%), post production (12%), marketing stakeholders (12%) and consumption (5%).

This report presents an amalgamation and analysis of national findings as well as a synthesis of ICT usage and uptake in agricultural value chains in the Caribbean, with innovative uses highlighted and the inclusion of some appropriate international best practices, which could serve as a reference for the region. The report also presents a comparison of e-readiness findings of the focal countries. e-readiness is defined as the ability and preparedness of the agricultural sector to use ICT for its modernisation. Additionally, elements for a regional e-agricultural strategy are proposed and a case is made for the need for a harmonised approach for the development and implementation of any proposed ICT integration strategy.

#### List of Case Studies

Case study 1: Ministry of Agriculture and Marine Resources website; Case study 2: Procurement management systems for the hospitality industry; Case study 3: Inventory management software; Case study 4: Text messaging system for wholesale prices; Case study 5: Digital display boards; Case study 6: National agricultural market information systems; Case study 7: NAREI BBM usage; Case study 8: Market and enterprise information system; Case study 9: Agriculture market information system (AMIS); Case study 10: Mobile messaging apps on smartphones; Case study 11: Livestock management mobile apps; Case study 12: Christiana Potato Growers Association; Case study 13: RADA Extension Service; Case study 14: Agricultural Business Information System (ABIS); Case study 15: CaFAN Agri-food Talkshow; Case study 16: Marketing and National Imports Board; Case study 17: Livestock tracking and traceability Namibia; Case study 18: Agricultural commodity exchange index Ghana; Case study 19: Drumnet; Case study 20: PestNet; Case study 21: Digital green; Case study 22: mFisheries; Case study 23: D'Market movers

*Available on CARDI Website* <http://www.cardi.org/wp-content/uploads/downloads/2014/11/Regional-synthesis-of-ICT-uptake-and-usage-in-agricultural-value-chains-in-the-Caribbean.-FINAL-Submitted-15-Oct-2014.pdf>

<http://www.cardi.org/cardi-publications/virtual-library/?did=607>

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**Tel:** 1-868- 645-1205-7. **Fax:** 1-868-645-1208. **Email:** [infocentre@cardi.org](mailto:infocentre@cardi.org)

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CGIAR

<http://tools4valuechains.org/>

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