CARDI

IMPROVING LIVES THROUGH
AGRICULTURAL RESEARCH

HQ/012/10

REVIEW

Issue 10, September 2010

Table of Contents

Foreword

There are three papers in this issue of CARDI Review; as is becoming a tradition with CARDI Review these papers are very diverse both in subject matter and presentation type.

Firstly there is the second of our series of invited papers; this is by Hugh Saul, Executive Director of the Caribbean Regional Fisheries Mechanism. This is a very comprehensive overview of the CARICOM fisheries sector with some controversial issues aired and clear suggestions as to moving forward. Secondly there is a research report on efforts in St Lucia to find a control method for the Red Palm Mite (*Raoiella indica* Hirst) which is having a devastating effect on coconut trees and some other plants in the Region. St Lucia was the first English speaking Caribbean country to report Red Palm Mite and the government quickly set up a project to research control methods. In common with many other exotic pests initial control attempts have not been too successful. Nevertheless it is important to fully report on these efforts; many international journals will not report results which are inconclusive, but CARDI feels that these results must be made as widely available as possible to guide future work and avoid repeating the same work. Lastly the issue of climate change is dealt with. In common with most of the World, the Caribbean has been slow to wake up to the dangers this poses to our livelihoods on the planet. Agriculture in the Region is under serious threat if the "do nothing" approach is taken. This CARDI Review paper attempts to show that by being proactive and aware, the threats and dangers can be converted to opportunities.

We hope that everbody who receives this issue enjoys reading these papers; if anybody has any views or comments to add to any of the three papers published, I will be very happy to receive these to share with the authors and, if appropriate, a wider audience.

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An overview of Caribbean fisheries

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ABSTRACT

CARICOM Member States and Associate Members occupy a total land area of 436,704km2 whereas the total area of the maritime waters under their jurisdiction is 2,041,708km2. This means that more than 82% of the area under jurisdiction is maritime space, which includes both the seabed and water column with their different ecosystems, living and non-living resources (CRFM 2003).

Fisheries in Member States of the Caribbean Community is strategically very important for sustained economic opportunities and social soundness particularly within rural communities and among the poor. Further, it shapes the culture of our people, and makes an important contribution to development and the attainment of food and nutrition security in the region. It is a prime source of animal protein for the population, with per capita consumption of fish in the region at between 23 kg and 25 kg per year, which is well above the world average (16.4 kg in 2005).

The sub-sector provides direct employment for more than 120,000 fishers and indirect employment opportunities for thousands of others (particularly women) in the processing, marketing, boat building, net making and other support services (CRFM 2005).

Annual nominal production of fish in the Caribbean ACP States has been growing steadily since the 1950s reaching about 195,000 tonnes valued at about US$600 million in 2000. The existing global economic stress coupled with the loss of preferential treatment for traditional crops such as sugar and bananas are taking their toll on CARICOM countries. Although fisheries may not be the answer to all our economic woes, it could become one of the answers. Fisheries account for up to 7% of some Member States' GDP. The true contribution is however, much higher since the processing and distribution aspects of the industry are not included in the fisheries sub-sector GDP. Fish processing, for example, is computed in the manufacturing and processing sector. Furthermore, these figures do not include the contribution of the recreational fishery, which is a rapidly growing sub-sector closely linked to tourism. The Bahamas estimate that recreational fisheries generate more than US$100 million in revenue each year.

Keywords: Caribbean fisheries, fish stocks

GLOBAL OVERVIEW

In 2006 capture fisheries and aquaculture supplied the world with 110 million tonnes of food fish, providing an apparent per capita supply of 16.7 kg (live weight equivalent), which is among the highest on record. Of this total, aquaculture accounted for 47%. Global capture fisheries production in 2006 was about 92 million tonnes, with an estimated first-sale value of US$91.2 billion, comprising about 82 million tonnes from marine waters and a record 10 million tonnes from inland waters.

Aquaculture continues to be the fastest growing animal food-producing sector. This assists food supply to outpace population growth, with per capita supply from aquaculture increasing from 0.7 kg in 1970 to 7.8 kg in 2006, an average annual growth rate of 6.9%. It is set to overtake capture fisheries as a source of food fish. From a production of less than 1 million tonnes per year in the early 1950s, production in 2006 was reported to be 51.7 million tonnes with a value of US$78.8 billion.

World per capita fish consumption has been steadily increasing from an average of 9.9 kg in the 1960s, 11.5kg in the 1970s, 12.5 kg in the 1980s. 14.4 kg in the 1990s, reaching 16.4 kg in 2005.

REGIONAL OVERVIEW

The maritime space of all CARICOM countries is substantially larger than the land areas. For example, the land area of Antigua and Barbuda is approximately 440km^2 whereas the area of the Exclusive Economic Zone (EEZ) is 110,103km^2, the land area of Barbados is approximately 430km^2 whereas the area of the EEZ is 167,384km^2, and the land area of Jamaica is approximately 11,000km^2, whereas the EEZ is approximately 300,000km^2. The total land area of the CARICOM Member States and Associate Members is 436,704km^2 whereas the total area of the maritime waters under jurisdiction is 2,041,708km^2. It is important therefore to note that about 80 per cent of the area under jurisdiction is maritime space, which includes both the sea bed and water column with different ecosystems, living and non-living resources (CRFM, 2003).

ECONOMIC IMPORTANCE OF THE FISHERIES SECTOR IN THE CARIBBEAN

The fisheries sector is an important contributor to income, employment, food security and social and economic stability, especially in coastal communities throughout the Caribbean. At the national level across the region, fisheries is an important contributor to the Gross Domestic Product (GDP) of many countries as well as an important foreign exchange earner.

The sector provides employment and livelihood opportunities for some of the most socio-economically disadvantaged in the Caribbean societies, including the least educated, rural poor, and women. Haughton (2007) reported that approximately 182,000 persons were employed by the fisheries sector (direct and indirect) throughout the region. The majority of those persons engaged in fishing often have low levels of formal education, limited access to capital and limited occupational and geographical mobility.

Table 1 presents an overview of fisheries in CARICOM Member Countries. Worthy of note is the per capita consumption. With a global average of 16.4 kg (2006) most CARICOM Countries per capita consumption is above that average, and when compared to the global average (2005) for developing countries (13.8 kg per capita), only one member country (Haiti) is below that average. The per capita consumption data is important, as it shows that CARICOM consumers have a high demand for fish, which is not the cheapest source of animal protein in the region.

STRUCTURE OF THE INDUSTRY

The structure of the fishing industry in the CARICOM region is characterised by:

- a large artisanal fisheries sector, where the majority of fisherfolk operate on a small scale basis concentrating on mostly primary production, utilising small boats and limited technology which is comprised of traps, cast nets and hook and line;

- an industrial fleet sector of large, modern, capital-intensive vessels which operate mainly in offshore areas, largely targeting high priced and value added species. Targeted species include spiny lobsters (The Bahamas, Belize and Jamaica), conch (The Bahamas, Belize, Jamaica and Turks and Caicos Islands), shrimp and prawns (Belize, Guyana, Suriname, and Trinidad and Tobago), tuna (wider Caribbean) and flying fish (Eastern Caribbean);

- an unquantified, recreational fisheries sub-sector spanning various aspects of tourism, including domestic and international sports fishing tournaments, yachting, fishing, weekend group and family fishing events. The Caribbean is rated by international magazines as a prime destination for international anglers for billfishes, such as marlins and sailfish, and for several other species of game fishes.

- a small but growing aquaculture sub-sector which is at varying stages of development in the different Member States (CARICOM 2002). Inland culture fisheries are more established in the larger territories, such as Jamaica and Belize where the dominant species are red tilapia and shrimp, respectively. Guyana and Suriname are seeking to establish a commercial aquaculture subsector. Less developed food fish culture exists in Dominica (shrimp), St. Lucia (sea moss and tilapia) and Trinidad and Tobago (tilapia);

- a processing, distribution and marketing sub-sector which, among other things, is an important source of value added production and employment especially for women and unskilled persons.

STATE OF THE FISH STOCKS

The magnitude and extent of the stocks in the Caribbean Sea are not well known, as the last extensive survey was carried out by FAO in the 1960's. However, in 1970, estimates of maximum sustainable yields (MSY) for demersal (bottom feeding fish), pelagic (surface feeders which move long distances) and shellfish resources ranged between 400,000 and 800,000 tonnes (CFU, 2004). CRFM (2004) notes that although data on the pelagic resources are limited (CFU, 2004), a UNDP / FAO study (1976) estimated that stocks in the area are probably as large as are the demersal fish resources. This indicates that total sustainable yields from fish stocks in the Suriname, Guyana and Trinidad and Tobago areas are about 260,000 tonnes, about 94% of which are in the Guyana - Suriname area.

The nature of the fisheries of the region, which stretches from Suriname to Belize and The Bahamas, is varied. It ranges from the shrimp and ground fish stocks off Guyana and Suriname to the pelagic stocks off Trinidad and Tobago and the Eastern Caribbean. The region also contains the reef species of the Eastern Caribbean, and the conch and lobster stocks of Jamaica, The Bahamas, Belize and the Turks and Caicos Islands. The migratory pelagic such as wahoo, tuna, flying fish and dolphin fish typically roam through the area (CRFM 2004).

Table 1 General information on some CARICOM countries

Country	Contribution of Fisheries to GDP (%)	Number of fishers	Total number of fishing boats	Fisheries production (tonne)	Fish import (tonne)	Fish export (tonne)	Total human consumption (tonne)	Per Capita
Antigua and Barbuda	1.70 (2003)	1,088 (2004)	728 (2004)	2,590 (2003)	2,520 (2003)	580 (2003)	3,530 (2003)	48.3 (2003)
Barbados	0.90 (1990)	2,200 (2000?)	955 (NFSO 2002)	2,500 (2003)	8,876 (2003)	272 (2003)	11,090 (2003)	41.1 (2003)
Belize	3.00	3,000 - 4,000 (2002?)	552 (NFSO2002?)	15,353 (2003)	1,467 (2003)	3,195 (2003)	3,625 (2003)	14.2 (2003)
Dominica	2.00 (1994)	2,338	1100 (NFSO2000)	1,142 (2000)	454.8 (2000)	N/A	1,596.8 (2000)	20.24 (2000)
Grenada	2.10 (1994)	1,240 (--)	N/A	2,544 (2003?)	2,360 (2003?)	738 (2003?)	4172 (2003?)	52.2 (2003?)
Guyana	6.63 (2002)	5,644 (2002?)	>1300 (2004)	60,304 (2003)	1,665 (2003)	27,012 (2003)	34,642 (2003)	45.7 (2003)
Haiti	N/A	50,000	N/A	5,000 (2003)	16,679 (2003)	337 (2003)	21,342 (2003)	2.6 (2003)
Jamaica	0.41 (2001)	15,336 (2004)	4,274 (2004)	8,702 (2003)	38,724 (2003)	928 (2003)	49,465 (2003)	18.7 (2003)
St. Kitts and Nevis	0.45 (1994)	650	N/A	370 (2003)	1,148 (2003)	23 (2003)	1,495 (2003)	35.6 (2003)
St. Lucia	0.75	2,059	690-most motorised (NFSO2006)	1,440 (2003)	3,303 (2003)	13 (2003)	4,753 (2003)	31.9 (2003)
St. Vincent and	0.90	2,500	600-most motorized (NFSO1999)	15,573 (1999)	1,102 (1999)	163 (1999)	1,711 (1999)	15.1 (1999)
Suriname	0.75	5,169	1,150 (NFSO2006)	15,856 (2003)	3,848 (2003)	12,580 (2003)	7,124 (2003)	16.3 (2003)
Trinidad and Tobago	0.09 (1993)	5,100	2,184 (NFSO2003)	9,743	12,993	4,478	18,257	14
Sources	CRFM	CRFM Unless stated	CRFM Unless stated	NFSO	NFSO	NFSO	NFSO	NFSO

Data for 2006 unless stated
CRFM: Caribbean Regional Fisheries Mechanism. NFSO: National Fisheries Sector Overview, FAO.
N/A: data not available

Within the Caribbean region most of the traditional commercially important species and species groups are reported to be either fully developed or over-exploited. These include queen conch, spiny lobster, shrimp, shallow shelf reef-fishes, snappers and groupers and some of the large pelagic species which are managed by the International Commission for the Conservation of Atlantic Tunas (ICCAT). There are, however, some species that are under-utilised such as some regionally distributed pelagic fishes, namely, wahoo (*Acanthocybium solandri*), dolphinfish, and blackfin tuna; squids such as the diamondback squid; deep-slope snappers and groupers, and some small coastal pelagic species including members of the carangidae, clupeidae, and engraulidae families (Haughton, 2004).

SECTOR HIGHLIGHTS

The fisheries sector presents many economic opportunities which are not exploited by CARICOM Member States. About 90% of our fishers are artisanal and most operate exclusively in the coastal waters of their Member States, seldom venturing beyond 50 miles of their 200 mile EEZ. By not fully exploiting their EEZ, Member States are abandoning parts of their EEZ to third states which have been illegally exploiting our fisheries and other marine resources.

Member States should jointly or in partnership with the regional private sector or international investors seek to promote and develop a CARICOM Regional Fishing Industry, thereby capturing all the economic, social and other advantages of such an industry. All Member States and their nationals stand to benefit from this development whether it be as consumers, workers or investors.

Food security

The living aquatic resources play a very important role in nutrition and food security within the Caribbean region. Fish is a vital source of animal protein and minerals in the diet of Caribbean people, particularly the poor and vulnerable members of society. The high diversity of species of different shape and size, the variation in taste and texture and broad range in the commercial value of fish, mean that fish is generally available at affordable prices to both rich and poor throughout the year. Per capita consumption of fish in the region is on average between 23 kg and 25 kg per year, which is well above the world average (16.4 kg in 2005).

Fish is nutritionally very important in that it provides a source of easily digested, high quality protein containing essential amino acids, particularly lysine, not easily obtainable elsewhere in such high concentrations. In addition the fats that fish contain are high in polyunsaturated fatty acids, particularly omega-3 fatty acids. According to medical experts, these have health benefits in protection against cardiovascular disease, assist in brain and nervous system development, in fetal and infant development and seem to offer some protection against diabetes, chronic infections and certain types of cancer.

Fish is a significant natural source of vitamins such as B12, A and E and a major source of naturally occurring vitamin D. Fish also contains important trace elements such as iodine and selenium. Fish is low in sodium, an important factor for persons with blood pressure problems who may require low sodium diets. Nutritionally therefore fish has a lot of advantages and in some rural coastal communities where other sources of animal protein are either scarce or expensive fish is often the most important source of dietary protein.

Fisheries production

Based on the available statistics, annual nominal production of fish in Caribbean States has been growing steadily since the 1950s reaching about 195,000 tonnes valued at about US$600 million in 2000. The existing global economic stress coupled with the loss of preferential treatment for traditional crops such as sugar and bananas are taking their toll on CARICOM Countries. Although fisheries may not be the answer to all our economic woes, it could become one of the answers. Fisheries account for up to 7% of some Member States' GDP. The true contribution is however, much higher since the processing and distribution aspects of the industry are not included in the fisheries sub-sector GDP. Fish processing, for example, is computed in the manufacturing and processing sector. Furthermore, these figures do not include the contribution of recreational fishery, which is a rapidly growing sub-sector closely linked to tourism. The Bahamas estimate that recreational fisheries generate more than US$100 million in revenue each year.

Exports

Exports of fish from the Caribbean region, presently valued at US$200 million have been growing steadily and in 2003 were valued at approximately US$150million; up from US$13.8million in 1986. The US market is the major destination for exports from the Caribbean. Export products are dominated by high-value commodities which command premium prices such as shrimp, spiny lobster, tunas, queen conch, deep-water red snappers and groupers. Generally, marine products with high economic value are exported, whereas products with high nutritive value and lower prices are imported to satisfy national needs. Caribbean fisheries are generally very competitive on the export market even with only negligible governmental support and almost no subsidies.

Imports

Total consumption of fish and fishery products in several of the Small Island Developing States (SIDS) is higher than local production and has to be satisfied by imports. Imports of fish and fishery products in Caribbean States were in excess of 90,000 tonnes in 2001. Imports are very high in some insular states and account for a large portion of the fish supplied for human consumption, for example Haiti and Jamaica import more than 60% of their needs. The composition of imports is dominated by dried, salted and smoked fish. Fresh, chilled and frozen products are also imported, mainly by the countries with relatively large tourist industries, including Jamaica, Barbados and St. Lucia.

Recreational fisheries and non-consumptive uses

Within the Caribbean region fisheries are important not only as a source of food and employment for commercial and subsistence fishers but also for a growing population of recreational fishers and diving enthusiasts. Recreational fishing is defined as fishing conducted for the purpose of pleasure and relaxation rather than for commercial gain or subsistence by the fisherman. Popular sport fishing magazines, such as Marlin, Salt Water Sportsman and Sport Fishing, consistently rate the Caribbean as a prime destination for international anglers for billfishes, such as marlins and sailfish, and for several other species of game-fishes. Dozens of international, regional and national fishing tournaments are held each year throughout the region. Antigua and Barbuda, The Bahamas, Belize, Barbados, Grenada, Jamaica, St. Lucia, Trinidad and Tobago and the Turks and Caicos Islands are among the popular sports fishing destinations in the region. Despite the popularity of sport fishing, there is a lack of data and information on the recreational fishing industry in the region. Research is needed to better understand the scope, economic importance and impact on the resource and management requirements of recreational fisheries in the region. According to the National Marine Fisheries Service (1996), in the US recreational marine fisheries and related industries are supported by annual direct expenditures of more than US$7 billion and provide more than one million jobs. The multiplier effect of these industries provides for billions of dollars in economic activity to the US.

The Caribbean is regarded as a top dive destination. Each year tens of thousands of tourists visit the region to dive or snorkel and observe the spectacular coral reef formations and diverse fish and other biological organisms inhabiting the reef ecosystems. Snorkeling, diving and watching coral reef fishes and other marine life are also becoming important leisure activities of thousands of local residents in the Caribbean. Over the past two decades, all CARICOM countries, with the exception of Guyana and Suriname, have established marine parks and aquaria to facilitate greater usage of the fish and marine ecosystems in a non-consumptive manner, to promote education and conservation of these aquatic resources systems, while at the same time generating employment and income. These have become major tourist attractions and marine biodiversity reserves throughout the region.

Aquaculture

Global aquaculture production valued at US$79 billion in 2006 and representing about 47% of global fish production is projected to overtake marine production and become the dominant contributor to fishery production. In order to satisfy the growing demand for fish at reasonable cost, to create employment, earn foreign exchange and diversify the economic base, Caribbean countries must expand into ecologically sustainable aquaculture. The potential for aquaculture both inland using freshwater and in the coastal areas using sea water and marine species (mariculture) is tremendous. Land that is suitable for sugar cane production is generally also suitable for aquaculture. The coastal waters are generally also suitable for a wide range of mariculture operations such as cage culture or seaweed farming. Capture fisheries will not be able to produce enough fish to meet growing demand because they are now at or beyond their sustainable limits. Expansion of aquaculture (including mariculture) production will not only help to meet high and growing demand for fish protein and employment, but should also reduce the pressure on wild stocks of fish and provide opportunity for recovery of over-exploited species, and also help to conserve marine biodiversity. Other countries, particularly in Asia but also in Latin America, with similar environments to the Caribbean have made significant advances and developed the techniques and technologies which can be adapted to the Caribbean situation.

IUU fishing

An OECD fisheries expert reported that Illegal, Unreported, and Unregulated (IUU) fishing is estimated as being as much as 20% of global catch. According to a BBC report, "China is the largest fisher in the world, and the illegal fishers would come second", exceeding legal fishing by bodies like the EU, Chile and Peru." (BBC Website, February 20, 2009).

In CARICOM, IUU fishing is estimated at between 17 and 20% of annual catch, accounting for between 33,150 and 39,000 tonnes per annum, valued at between US$105 million and US$124 million (at 2000 prices).CRFM has prepared a Non-Binding Draft Declaration aimed at promoting regionally coordinated action to combat IUU fishing and is awaiting endorsement by Member States.

Common fisheries policy

In 2003 the Fourteenth Inter-Sessional Meeting of the Conference of Heads of Government in Trinidad and Tobago, mandated the preparation of a Common Fisheries Policy and Regime (CFP&R) for CARICOM countries. The substance of the mandate is that there should be developed a regional framework for the exploitation and conservation of fisheries resources in the region based on the following guidelines:

- there should be a common maritime authority to manage the resources, cooperate in research and provide technical support for ongoing fisheries projects in the region;
- operation in the fishery zone should be done under licence;
- research should establish the allowable yearly sustainable catch;
- a quota system will guarantee sustainable harvesting;
- catches and landings should be recorded;

- operation without licence should be illegal and punishable;
- technical standards (e.g. types of fishing gear and vessels) and best practices are required to ensure the sustainability of the resources;
- there should be a clear, transparent and closely monitored policy for the granting of any fishing access to third countries i.e. non-CARICOM countries;
- security procedures should be put in place to require reporting by fishing vessels to Coast Guard, Customs and Immigration when entering and leaving national jurisdictions;
- common approach and understanding on regional and international matters relating to fisheries management, governance, exploitation and surveillance.

Since 2003 the CRFM and CARICOM Secretariats have spearheaded the preparation of the CFP&R through a consultative process involving a series of studies, consultations among stakeholders, and regional meetings involving officials of Member States and regional experts in fisheries, foreign affairs, law and marine policy. However the process has suffered inordinate delays as some Member States have shown less than wholehearted commitment to the development of a common regional policy for the fisheries sector.

ISSUES

Although the sector is strategically important and offers great potential for enhanced contribution to the social and economic development of the region, it nevertheless faces numerous challenges, among which are:

- The perceived low priority accorded to the sector in most countries. This translates into inadequate and uneven funding contribution and support to the sector overall and the CRFM Secretariat.
- In many cases the national fisheries departments are inadequately staffed and equipped to discharge their mandates of governance and sustainable development, management of the fisheries resources and to provide leadership to the industry.
- There are concerns regarding the inordinate delays and perceived low level of interest among some Member States in completing the Common Fisheries Policy and Regional Declaration to combat Illegal, Unregulated and Unreported Fishing. These documents are regarded as basic instruments that will facilitate and promote the transformation of the sector to achieve increased production and productivity and global competitiveness, while also improving the socio-economic well-being of fisherfolk and fishing communities and contributing to food security.

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Field trials to determine the efficacy of three chemicals in the control of the Red Palm Mite (*Raoiella indica* Hirst) on coconut (*Cocos nucifera*) in Saint Lucia

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ABSTRACT

Field trials were conducted at several sites in St. Lucia with the aim of investigating the efficacy of four readily available chemicals (GC-Mite, Kumulus, Lime Sulphur and Safe Oil) in the control of the Red Palm Mite (*Raoiella indica* Hirst). The trials were conucted from mid 2007 to the end of 2008. Results demonstrated that Safe Oil gave the best control for the first half of the experimental period with GC-Mite being the least effective, but in the final 3 months Kumulus and Lime Sulphur seemed to give the best control.

INTRODUCTION

The first report of the Red Palm Mite (*Raoiella indica* Hirst) in the Western Hemisphere was in 2004 from the Eastern Caribbean island of Martinique (Flechtmann and Etienne 2004, 2005). The mite was subsequently confirmed on the islands of Saint Lucia and Dominica in 2005 (Kane et al. 2005).

In Saint Lucia, Kane and Ochoa (2006) observed that in coconuts, mite populations were located on the underside of leaflets, with a higher number on the lower leaves. Mites were located in groups, ranging in number from 20 to 300 individuals. The explosive appearance of the Red Palm Mite in the region represents a serious pest risk to crop productivity and food security in the entire Caribbean and the subtropical regions of the Americas (Pena et al. 2006).

Current knowledge of the effectiveness of chemical control of the Red Palm Mite is based entirely on research in India and the Near East. The methods developed in that research may not be applicable to most plantations or the undulating landscape situations typical of most of the Caribbean islands.

In India, the application of neem oil sprays mixed with sulfur after a thorough cleaning of the coconut crown showed good results. The extract is sprayed from above, 5 to 6 times per year, but is possible with a sprayer-head attached to a long pole (Devusahayam and Nair 1982; Sarkar and Somchoudhury 1988).

Keywords: Red Palm Mite, St. Lucia, GC-Mite, Kumulus, Lime Sulphur, Safe Oil

Chemical applications are used on occasions of high density of the mite when it is affecting date palm in the United Arab Emirates (Gassouma 2005).

Chemical control of other Tenuipalpidae in crops such as citrus have shown that, in combination with petroleum oil, pyridaben, fenbutatin-oxide, dicofol or high rates of sulfur give at least 35 days of control of Red Palm Mite (Childers 1994).

MATERIALS AND METHODS

Seven sites were located to conduct the treatments: these sites were in five of the eight agricultural regions of St. Lucia. At each site each treatment was applied to a replicate plot of two trees. Each tree was labeled and data referenced to include data such as GPS positioning including altitude, tree height, number of nuts and variety.

Four treatments were used in this trial. Treatments were applied monthly from the first treatment in September 2007 to the final treatment in December 2008 (sixteen treatments in all). The chemicals utilised in the trial were GC-Mite, Kumulus, Lime Sulphur and Banana Safe Oil.

GC-Mite is a botanical broad spectrum, contact miticide and insecticide for the control of most types of mites, aphids, thrips and other insects. It also dissolves spider mite webs and controls their eggs. It is constituted of 40% Cottonseed oil, 20% clove oil, 10% garlic extract and 30% inerts of water, casein, lecithin and soy flour.

Kumulus is a dry flowable sulphur fungicide that prevents powdery mildew and other fungal diseases and controls mites on fruits and vegetables. The formulation contains 80% sulphur.

Lime Sulphur is a fungicide composed of inorganic sulphur and lime and has been used since the 19^{th} Century to control a variety of plant pests and diseases.

Banana Safe Oil is a mineral oil derived as a by-product from the distillation of petroleum from crude oil. It is a transparent, colourless liquid. Pesticides with mineral oil as the active ingredient are used as insecticides and acaricides for treating trees and shrubs. Products with mineral oil as the active ingredient may be used to control various pests, such as scales, aphids, mites and white flies. Mineral oil may act on pests by blocking their respiratory systems, destroying the waxy coating on their bodies, interfering with their feeding or by discouraging them from laying eggs. It can also smother eggs laid on plants.

The rate of application of the chemicals depended on the age and size of the trees. For fully grown trees GC-Mite and Kumulus were sprayed at a rate of 12ml/tree, Lime Sulphur and Safe Oil at 30ml/tree. These rates were halved for the younger, smaller trees. All applications were made with the use of motorised back pack mist blowers. The PL-50BV atomiser and duster is provided with a centrifugal pump which provides a constant chemical flow, independent of the application lance orientation and liquid level in the tank.

At each site there were trees which acted as buffers between trees which were treated. Buffer trees were not sprayed with any liquid.

Leaf samples were collected from coconut fronds 3 and 9. One leaflet was taken from the middle section on each side of the rachis from both leaf 3 and 9, for a total of four leaflets per tree. These samples were then separately bagged and labeled accordingly before placement in an ice chest for transportation to the laboratory.

Samples were collected 1 and 3 weeks after treatment with all samples counted within a 24 hour period. The laboratory sampling procedure included recording the length of each leaflet, then cutting each into four sections of equal length, with each section being examined under the stereoscope zoom microscope, model DC3-42OTH, and the resulting direct mite counts recorded onto trial data sheets.

At each site observations were taken 1 week before treatment applications to verify or otherwise the presence of Red Palm Mite on the trees. All sites were heavily infested before treatment application.

RESULTS AND DATA ANALYSIS

All the variables, i.e. eggs alive, eggs dead, total eggs, juveniles alive, juveniles dead, total juveniles, adults alive, adults dead, total adults, predators alive, predators dead, total predators were analysed using repeated measures ANOVAs for the 16 months of treatment.

The repeated measures were the counts taken 1 and 3 weeks after each treatment. However for treatment 4 (December 2007) no samples were taken and no counts observed 3 weeks after the treatment. All counts were transformed to logarithms before analyses [$y= \log_{10} (x+1)$].

Factors examined in the repeated measures ANOVA were differences in treatment (GC-Mite, Kumulus, Lime Sulphur, Safe Oil), time (times of observation as described above) and the interactions between these factors. The effect of leaf (third versus ninth) and interactions with leaf were never significant.

Eggs

The mean numbers of eggs alive per sample 1 and 3 weeks after each treatment (except 3 weeks after treatment 4) are shown in Table 1. In 2007, the Safe Oil treated leaves gave significantly lower counts ($P \leq 0.05$) than the other treated leaves. This effect, however, was not observed in 2008; after treatment 6, the pest infestation worsened and this can be observed in the eggs alive in Table 1. During most of 2008, there were no significant differences ($P>0.05$) in the number of eggs alive for samples of leaves on which the different treatments were applied. During the final quarter of 2008, the counts (and infestation) was lower and during this time Kumulus and Lime Sulphur treated leaves gave lower numbers ($P \leq 0.05$) than those from leaves treated with GC-Mite and Safe Oil.

The number of eggs dead was usually very small. At no time was the mean number of eggs dead observed on the samples of leaves greater than three and usually it was less than one.

Juveniles

The mean numbers of juveniles alive per sample 1 and 3 weeks after each treatment (except 3 weeks after treatment 4) are shown in Table 2. The trends here are very similar to the trends observed for eggs. Safe Oil treated leaves gave significantly lower numbers than the other treatments ($P \leq 0.05$) during 2007; however this effect disappeared in 2008, especially when all numbers became higher after treatments 7 and 8. At the end of the year (2008) when counts declined again, Kumulus treatment gave lowest numbers with Lime Sulphur also significantly lower ($P \leq 0.05$) than GC-Mite and Safe oil.

The mean numbers of juveniles dead from the samples was always less than one.

Adults

The mean number of adults alive per sample 1 and 3 weeks after each treatment (except 3 weeks after treatment 4) are shown in Table 3. Here the lower observed ($P \leq 0.05$) mean for leaves from trees sprayed with Safe Oil was again observed for 2007 and continued during the first month of 2008. After that the numbers increased with GC-Mite treated leaves giving even higher ($P \leq 0.05$) counts than those from the leaves from trees from the other treatments (Kumulus, Lime Sulphur and Safe Oil). At the end of 2008 counts from Kumulus and Lime Sulphur plots were significantly lower ($P \leq 0.05$) than those from GC-Mite and Safe Oil treated plots.

In common with eggs and juveniles, the number of dead adults observed was usually small. The highest observed mean counts per treatment during the experiment was 5.8.

Predators

Throughout the experiment very few predators were observed. The mean number of live predators was below zero for 75% of the means for the treatments at the different sampling trees and the highest mean was 3.4. The mean number of dead predators was always zero (or close to zero).

DISCUSSION

This experiment did not lead to the conclusion that any of the chemicals tested was consistently effective against *Raoiella indica*. At the beginning of the trial Safe Oil was the most effective, but partial control achieved by this chemical did not continue when infestation rose during 2008.

The end of both years (2007 and 2008) saw the lowest counts of eggs, juveniles and adult *Raoiella indica*. During the lower counts of late 2008 Kumulus and Lime Sulphur appeared to be giving some measure of control when compared with GC-Mite and Safe Oil.

Throughout the experiment GC-Mite was never effective and leaves from plants treated with GC-Mite often gave the highest counts of eggs, juveniles and adult *Raoiella indica*.

Table 1 Mean number of eggs alive observed on samples of coconut leaves taken throughout the experiment

		Treatment Applied			
		GC-Mite	**Kumulus**	**Lime Sulphur**	**Safe Oil**
2007	1 week after treat 1	46.1	35.6	18.9	22.3
	3 weeks after treat 1	45.3	22.7	34.1	14.6
	1 week after treat 2	25.7	19.3	4.9	3.1
	3 weeks after treat 2	16.4	47.0	80.3	6.6
	1 week after treat 3	33.4	31.3	15.7	3.1
	3 weeks after treat 3	27.2	57.8	19.6	12.0
	1 week after treat 4	29.6	85.1	21.2	0.0
2008	1 week after treat 5	29.1	48.3	28.1	20.4
	3 weeks after treat 5	30.8	51.1	38.7	39.9
	1 week after treat 6	36.0	29.1	40.7	49.9
	3 weeks after treat 6	105.3	87.1	73.6	72.2
	1 week after treat 7	93.0	68.8	38.6	53.5
	3 weeks after treat 7	75.0	43.6	19.8	49.3
	1 week after treat 8	130.1	57.8	40.0	77.5
	3 weeks after treat 8	89.5	81.2	108.8	112.0
	1 week after treat 9	86.4	55.8	50.5	55.1
	3 weeks after treat 9	53.5	41.7	29.1	31.6
	1 week after treat 10	24.9	32.8	32.7	27.6
	3 weeks after treat 10	146.5	75.8	68.8	100.8
	1 week after treat 11	54.6	84.1	61.3	77.2
	3 weeks after treat 11	51.4	42.4	17.9	28.6
	1 week after treat 12	59.9	44.2	31.6	34.3
	3 weeks after treat 12	70.9	26.4	48.9	48.4
	1 week after treat 13	90.1	23.4	48.9	34.8
	3 weeks after treat 13	32.9	4.1	18.8	47.8
	1 week after treat 14	32.5	8.0	33.5	38.8
	3 weeks after treat 14	25.5	6.5	7.4	26.6
	1 week after treat 15	34.1	4.7	2.3	24.0
	3 weeks after treat 15	17.4	7.6	14.5	33.9
	1 week after treat 16	24.4	23.0	11.1	30.1
	3 weeks after treat 16	29.4	5.6	17.1	29.4

Table 2 Mean numbers of juveniles alive observed on samples of coconut leaves taken throughout the experiment

		Treatment Applied			
		GC-Mite	Kumulus	Lime Sulphur	Safe Oil
2007	1 week after treat 1	7.9	9.4	5.6	3.4
	3 weeks after treat 1	6.0	3.1	5.1	3.8
	1 week after treat 2	4.9	6.8	1.1	0.8
	3 weeks after treat 2	2.6	7.0	9.0	1.3
	1 week after treat 3	6.7	5.2	1.6	0.6
	3 weeks after treat 3	3.6	7.7	2.2	2.2
	1 week after treat 4	5.0	17.0	3.8	0.0
2008	1 week after treat 5	4.3	8.5	2.5	3.6
	3 weeks after treat 5	3.6	6.3	4.5	5.1
	1 week after treat 6	4.2	4.2	4.6	4.4
	3 weeks after treat 6	8.6	15.1	6.6	6.5
	1 week after treat 7	14.1	12.0	4.7	12.1
	3 weeks after treat 7	10.5	4.7	4.0	6.7
	1 week after treat 8	19.7	8.6	3.8	18.9
	3 weeks after treat 8	17.0	14.7	19.9	25.2
	1 week after treat 9	11.5	7.6	12.1	10.6
	3 weeks after treat 9	8.2	7.5	4.6	3.8
	1 week after treat 10	6.6	4.7	5.0	5.1
	3 weeks after treat 10	35.0	7.9	12.3	21.2
	1 week after treat 11	14.1	8.9	11.5	11.8
	3 weeks after treat 11	10.8	6.4	4.2	7.1
	1 week after treat 12	9.9	7.5	3.8	4.6
	3 weeks after treat 12	13.6	5.1	14.1	10.8
2009	1 week after treat 13	16.1	2.9	6.1	6.0
	3 weeks after treat 13	8.0	0.6	3.1	6.6
	1 week after treat 14	5.9	1.7	6.0	4.7
	3 weeks after treat 14	4.4	0.6	1.4	4.6
	1 week after treat 15	6.6	0.7	0.3	4.3
	3 weeks after treat 15	3.7	1.6	3.0	7.0
	1 week after treat 16	4.3	2.7	1.4	3.8
	3 weeks after treat 16	6.2	1.0	4.4	5.6

Table 3 Mean numbers of adults alive observed on samples of coconut leaves taken throughout the experiment

		Treatment Applied			
		GC-Mite	Kumulus	Lime Sulphur	Safe Oil
2007	1 week after treat 1	27.9	31.1	12.3	15.6
	3 weeks after treat 1	33.5	15.9	33.6	7.6
	1 week after treat 2	18.2	15.9	3.8	1.7
	3 weeks after treat 2	15.0	27.3	56.6	5.3
	1 week after treat 3	39.2	31.8	14.2	3.0
	3 weeks after treat 3	35.3	34.5	13.1	11.2
	1 week after treat 4	28.4	41.8	22.2	0.0
2008	1 week after treat 5	27.5	52.7	37.2	17.1
	3 weeks after treat 5	29.2	47.0	42.6	27.1
	1 week after treat 6	35.0	17.2	38.4	35.1
	3 weeks after treat 6	79.3	84.1	53.8	75.6
	1 week after treat 7	70.5	86.9	42.0	50.5
	3 weeks after treat 7	61.2	48.8	35.5	42.2
	1 week after treat 8	121.6	53.9	48.4	76.4
	3 weeks after treat 8	121.2	111.8	89.7	110.9
	1 week after treat 9	90.6	63.7	64.5	65.5
	3 weeks after treat 9	40.5	32.6	15.6	29.4
	1 week after treat 10	36.3	25.8	37.1	33.4
	3 weeks after treat 10	144.6	68.9	71.5	93.4
	1 week after treat 11	100.6	122.5	72.9	93.7
	3 weeks after treat 11	57.9	41.9	31.2	39.3
	1 week after treat 12	53.2	47.5	29.3	37.4
	3 weeks after treat 12	78.1	27.9	49.7	40.0
	1 week after treat 13	98.1	19.0	30.6	44.2
	3 weeks after treat 13	35.1	4.3	26.6	63.1
	1 week after treat 14	34.7	11.7	39.0	47.8
	3 weeks after treat 14	38.1	10.8	10.1	33.9
	1 week after treat 15	33.8	6.3	4.0	20.7
	3 weeks after treat 15	25.0	15.3	22.4	30.3
	1 week after treat 16	23.8	22.0	14.4	35.9
	3 weeks after treat 16	22.6	7.6	18.8	30.5

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Climate change and agriculture in the Caribbean: approaches and opportunities for sustainable development in the 21st Century

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ABSTRACT

There is enough evidence to conclude that climate in the Caribbean is changing in line with global trends. The effect of this is already being felt by agricultural producers in the region. A planned response to this changing climate has, as yet, not been developed and articulated. In the Caribbean, agriculture still remains a very important component of the socio-economic well-being of most of the people and so a meaningful response to the impending dilemma is imperative. Agricultural production systems are part of a wider natural ecological system and must exist in harmony with it if agricultural production is to be enhanced. This requires a conscious shift to more ecologically friendly agricultural production systems. In this presentation the principles of a sustainable agricultural system in the region are described. This is then followed by examples of sustainable practices which are already in used or are being assessed in the region in relation to mitigating and adapting to climate change.

INTRODUCTION

Trotz (2008) reported that results from studies done by the Institute of Meteorology (INSMET) in Cuba and the University of the West Indies (UWI) indicate that the region is warming; the diurnal temperature range is decreasing; the number of warm days in the region is increasing but the number of very cold nights is decreasing; the frequency of droughts is increasing and the frequency of extreme events in the region seems to be changing. With respect to the latter, flooding events and hurricane passage through the region have increased since the mid 90's (Trotz 2008).

Farmers in the Caribbean have been seeing some of these hazards manifesting themselves particularly in the last 5 years. Some climate change phenomena being observed by the farming community presently include:

- Variable rainfall conditions with alternating droughts and periods of excess rainfall.
- Increased number and intensity of tropical storms.
- Resulting flooding of lowlands, landslips and loss of valuable topsoil and crops.

Keywords: Caribbean, sustainable agricultural practices, climate change, environment, agriculture

The Caribbean as a region still depends heavily on agriculture for its economic development, and to provide safe, healthy foods for its people. The percentage contribution of agriculture to Gross Domestic Product (GDP) varies widely among countries in the Caribbean: from over 20% for Haiti, Guyana and Dominica to less than 5% for Trinidad and Tobago, Antigua and Barbuda and Barbados (CDB 2003). A large percentage of the work force of all these islands is, however, involved in agricultural activities. In the future, agriculture's contribution to the regional economy will have to be increased to address the large food import bill of the Region. Adapting to the changing climate is, therefore, critical to socio-economical survival.

The challenges to the regional agricultural sector though multi-facetted are to some extent related and can be overcome by adopting agricultural practices which are sustainable in every sense. Sustainable agriculture has traditionally been defined in terms of its economic viability and long term ability to preserve the environment. In the present circumstances sustainability has to now embrace survival in a physical and economic environment which is changing and in most cases becoming more hostile. It also has to embrace a greater role in preserving the environment by moving from being one of the important Greenhouse Gas (GHG) emitters (Greenhouse Gas Working Group, 2010) to becoming a net carbon sink, by offering options for mitigating climate change.

This paper will detail the sustainable agricultural practices and approaches which can provide the results required from the discourse above. Examples of some of these approaches which are already in use or are being assessed by the Caribbean Agricultural Research and Development Institute (CARDI) in the region are highlighted. These signify some of the opportunities for the future development of agriculture in the region.

DEFINING SUSTAINABLE AGRICULTURAL PRACTICES

The economic activity of agriculture is carried out in the midst of a very complex system of nature which brings together biological, geologic, hydrologic, and atmospheric components. Among these components are trees and other plants; animals, insects, and microorganisms; rocks, soil, minerals, and landforms; water in the ground and on the surface, flowing or in a reservoir; wind, sun, rain, moisture; and all the other specifics that make up weather and climate.

Traditional agricultural practices have been largely geared towards entering this intricately balanced system, destroying all that is considered undesirable and implanting the crop of economic importance. In this now unbalanced system the agriculturalist treats any other plants which emerge as weeds, the imbalance in insect populations as a result of monoculture give rise to insect pests and diseases which are treated with pesticides. Soil clearing methods that do not preserve the organically rich topsoil lead to loss in soil fertility which is inadequately compensated for by applying inorganic chemical elements.

Sustainable agricultural practices attempt to maintain, utilise and support the natural ecological system while promoting an economic cropping enterprise. Sustainable agricultural systems have been given various names depending mainly on the degree to which the practices attempt to maintain the natural system. Examples of these are:

Agroecology - linking ecology, culture, economics, and society to sustain agricultural production, healthy environments, and viable food and farming communities (Gliessman 1998).

Organic agriculture - a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved (IFOAM 2008).

Ecological agriculture - the practice of ecological agriculture involves building the strengths of natural ecosystems into agroecosystems, purposely disturbed to produce food and fibre. The overall strategies include using practices that (a) grow healthy plants with good defence capabilities, (b) stress pests, and (c) enhance populations of beneficial organisms (Magdoff 2007).

Biological agriculture: the production of plants and animals and the use of raw materials in harmony with natural control mechanisms (Davis 2003).

For the purposes of this discussion it is the author's view that the sustainable agricultural systems that are likely to be beneficial to agriculture in the region will come from a combination of practices most suited to overcoming present and emerging challenges and should:

- Make best use of nature's goods and services by integrating natural, regenerative processes, e.g. nutrient cycling, nitrogen fixation, soil regeneration and natural enemies of pests.
- Minimise non-renewable inputs (pesticides and fertilisers) that damage the environment or harm human health.
- Depend on locally-adapted practices to innovate in the face of uncertainty.
- Be multifunctional and contribute to public goods, such as clean water, wildlife, carbon sequestration in soils, flood protection and landscape quality.
- Rely on the knowledge and skills of farmers, improving their self-reliance.

Sustainable agricultural practices include:

- Crop rotations that mitigate weed infestation, disease, and insect problems; increase available soil nitrogen and reduce the need for synthetic fertilisers; and in conjunction with conservation tillage practices, reduce soil erosion.
- Integrated Pest Management (IPM), which reduces the need for pesticides by crop rotations, scouting, timing of planting, biological pest controls.
- Management systems to improve plant health and crops' abilities to resist pests and diseases.
- Soil conserving tillage.
- Water conservation and water harvesting practices.
- Planting of leguminous crops and use of organic fertiliser or compost to improve soil fertility.

SUSTAINABLE AGRICULTURAL SYSTEMS AND CLIMATE CHANGE

Sustainable agricultural systems are likely to be effective in management of climate change through mitigation which is the reduction of greenhouse gas in the atmosphere through reduced emissions and the storage of carbon in soils and plant material and also by helping cropping systems to adapt to adverse effects of a changing climate. Sustainable agriculture reduces harm to the environment, for example through the reduction or elimination of polluting substances such as pesticides and nitrogen fertilisers, water conservation practices, soil conservation practices, restoration of soil fertility and maintenance of biodiversity.

Importantly, sustainable agricultural practices can also mitigate climate change. Organic agriculture, for example, uses less fossil fuel-based inputs and has a better carbon footprint than standard agricultural practices. This is because conventional agriculture production utilises more overall energy than organic systems due to heavy reliance on energy-intensive fertilisers, chemicals, and concentrated feed, which organic farmers forego (Zeisemer 2007). Organic agriculture performs better than conventional agriculture on a per hectare scale, both with respect to direct energy consumption (fuel and oil) and indirect consumption (synthetic fertilisers and pesticides), with high efficiency of energy use (Scialabba and Hattam 2002).

Sustainable agricultural systems have great mitigation and adaptation potential, particularly with regard to soil organic matter fixation, soil fertility and water-holding capacity, increasing yields in areas with medium to low-input agriculture and in agro-forestry, and by enhancing farmers' adaptive capacity. In general the benefits are of a threefold nature:

1. Carbon dioxide is removed from the atmosphere (mitigation);
2. Higher organic matter levels in soil enhance its resilience (adaptation);
3. Improved soil organic matter levels lead to better crop yield (production).

For farmers who have to face increased climate variability and extreme weather events in the near future, sustainable agriculture, by increasing resilience within the agroecosystem, increases its ability to continue functioning when faced with unexpected events such as increasing temperatures and drought conditions. For example, organic agriculture builds adaptive capacity on farms as it promotes agroecological resilience, biodiversity, healthy landscape management, and strong community knowledge processes (Borron 2006). Improved soil quality and efficient water use also strengthen agroecosystems, while practices that enhance biodiversity allow farms to mimic natural ecological processes, which enable them to better respond to change. Sustainable farming practices that preserve soil fertility and maintain, or even increase, organic matter in soils can reduce the negative effects of drought while increasing crop productivity (Niggli et al. 2008).

SUSTAINABLE AGRICULTURAL PRACTICES IN JAMAICA AND THE CARIBBEAN

In the Caribbean research has been steering production into more sustainable systems over the years in such areas as integrated pest management (Jackson et al. 2002), biological nitrogen fixation (Schroder 1992) and the use of green manures (Simpson and Wickham 2002). This movement has now to be rapidly increased as the region attempts to alleviate the potentially disastrous effects of climate change. Some of the practices already in use or being assessed in the Caribbean are detailed below.

Promoting soil health for agricultural production on reclaimed bauxite soils using integrated crop/ livestock systems

Bauxitic soils comprise over 20% of the total surface of Jamaica (Lyew-Ayee and Stewart 1982). These soils, when mined and reclaimed, will represent a significant proportion of the productive lands and must be returned to full productivity as soon as possible to ensure the economic well being of the country.

Reclaimed bauxite soils in Jamaica are shallow, relatively infertile, free draining and prone to erosion. They therefore require management practices which will allow the economic production of crops while sustaining and enhancing the soil resource and the environment. Because of the nature of these soils they have traditionally been used for the growing of pasture species to sustain ruminant livestock production.

From its inception in 2000, the Sam Motta Demonstration and Training Centre (SMDTC) has shown that reclaimed bauxite lands can be used to grow forages for livestock production. In recent years, using an integrated crop/livestock approach the station has been demonstrating that the soils can be utilised sustainably for both crop and livestock production (CARDI 2008). Economically viable yields of food crops such as callaloo, sweet pepper, corn, carrots and hot pepper have been demonstrated on small plots. Production practices conducted within these small plots include the use of compost made from goat manure, mulches and a structured rotation plan to enhance soil health. In addition, biologically based pest management strategies were employed. A beneficial plant garden which has several herbs and spices plants was established to attract and increase the persistence of biological control agents within the cropping area. Soil and water conservation methods including mulching and drip irrigation are also employed in an effort to maximise production.

In this integrated approach crop and livestock by-products from production are utilised so that:

- Manure and crop residues are used in composts that are applied to crops to supply nutrients and improve soil health and fertility.
- Crop by-products serve as a source of food for goats
- Some of the grasses from the forage system are used as mulch to reduce water and soil loss.

In addition, orchard crops are to be included to provide shade for the animals while also providing a source of income.

Mulch farming in St Elizabeth, Jamaica

The Parish of St Elizabeth in Jamaica is considered the food basket of the island, as it provides a large percentage of the island's food crop production. Coincidentally, it is also the driest parish in the island with rainfall averaging 1,450 mm per annum compared to 2,000 mm in most of the other parishes. Farmers in the south part of the parish practice a unique form of dry land farming. Guinea grass is cultivated as a mulch crop, and this is either transported to the planting area or used in situ after cutting (Plate 1). Crop plants are introduced directly into plant holes which are dug through the mulch material. There is limited irrigation during crop growth and the mulch helps to conserve soil water which is obtained from rainfall. These cultural practices were developed as a result of the dry conditions and produce economically acceptable yields in the area.

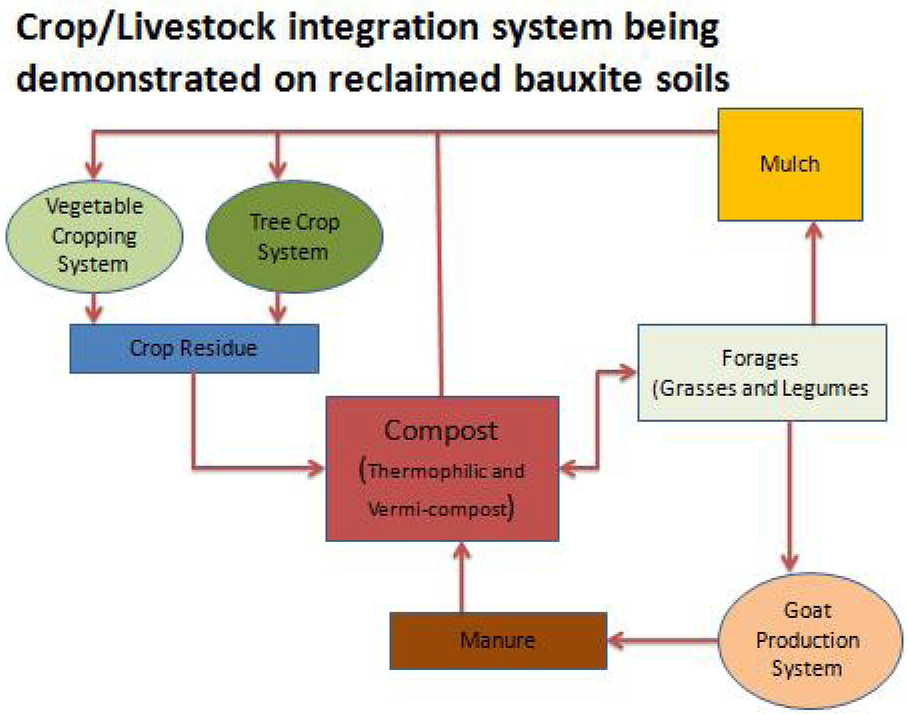

Figure 1 The crop/livestock integration system being demonstrated at the Sam Motta Demonstration and Training Centre (SMDTC)

Multiple cropping to increase resilience in the ecosystem

Multiple cropping is practiced by many small farmers in the Caribbean. This practice decreases vulnerability by increasing the likelihood of one of the several crops being able to tolerate hazardous climatic conditions. This practice is also important in managing the risk of pest and disease infestation as the diversity of crops also increases the diversity of associated insects and this increases the resilience of the system and makes it more akin to a natural ecological system. Plate 2 indicates a farmer with several different plant species in one field.

Plate 1 Mulch farming in St Elizabeth Parish, Jamaica

Under the changing climatic conditions multiple cropping is also evolving into the planting of contrasting crops. In the Parish of St Thomas in Jamaica, a farmer was observed to be planting eddoes in holes on a bed that also had pineapples. Eddoes are usually grown under wet swamp conditions, while pineapples enjoy a very dry, arid climate. The farmer was preparing for the extremes of both flood and drought in his crop selection (Plate 3).

Plate 2 Multi-cropping to increase ecosystem resilience

Plate 3 Planting contrasting crops for risk management

Integrated Pest Management (IPM) using trapping, exclusion, biological control and reducing pesticide application

The CARDI Jamaica Unit under the USAID-sponsored Integrated Pest Management Collaborative Research Support Program (IPM CRSP) has worked on the vegetable amaranth (callaloo), hot pepper and sweet potato to develop Integrated Pest Management (IPM) options. The IPM options emphasise the use of physical, cultural, biological and other non-chemical methods of pest management. Chemical pesticides are only used as a last resort. The various IPM non-chemical methods, exclusion, pheromone traps, sticky traps and biological control are shown in Plate 4.

In callaloo, the IPM strategy was of a twofold nature. The first strategy utilised exclusion technology. The exclusion cage leads to a 60%-100% reduction in pesticide use and virtually eliminates insect damaged losses in production of this crop. The design also incorporates features for disaster mitigation which allow for easy dismantling in the event of approaching storms or hurricanes.

In sweet potato, the major pest Cylas formicarius (sweet potato weevil) was managed using an IPM strategy based on non-chemical approaches viz. cultural methods and a sex pheromone trap. This system has virtually eliminated the weevil as a major pest in sweet potato production in Jamaica. Further research indicated that a “home-made” trap which could be made by farmers was just as effective as the commercial traps.

The Coffee Industry Board funded project on the biological control of the Coffee Berry Borer, Hypothenemus hampei Ferrari in Jamaica was geared towards reducing losses to the coffee industry by the Coffee Berry Borer (CBB), and providing a safe alternative to the traditional pesticide Endosulfan which was not environmentally friendly. The strategy used was classical biological control using parasitoids of the CBB. Three hymenopteran parasitoids were introduced, reared, released and established. Coffee industry personnel were sensitised and trained in aspects of biological control. A model was also proposed for incorporation of biological control into IPM of coffee pests. This system has not found widespread use in the coffee industry, but did demonstrate that there are other possibilities besides the use of agrochemicals.

Plate 4 IPM non-chemical methods, exclusion, pheromone traps, sticky traps and biological control

Organic agriculture which increases organic carbon storage in soils

The approach to plant nutrition in organic agriculture is fundamentally different from the practices of conventional agriculture. While conventional agriculture aims at providing direct nutrition to the plants by using mostly easily soluble mineral fertilisers, organic farming feeds the plants indirectly by feeding the soil organisms with organic matter.

Plate 5 An organic-rich topsoil layer, that is only possible under sustainable management practices

Over a period of 6 years, CARDI evaluated the performance of various manures and vermi-compost on the production of callaloo (*Amaranthus* spp.) and hot pepper (*Capsicum chinense*). These manures were cow manure, goat manure, vermi-compost and a commercial organic fertiliser (Simpson 2009). The continuous use of the manures as well as organic mulches increased the organic matter content of the top 15 cm of soil from 1.9% to 2.9% in the 6 years. Estimating the mass of dry soil in a 15-cm depth over an hectare as 2,250,000 kg, this 1% increase will be equivalent to 22,500 kg of organic matter or over 12,000 kg of organic carbon per hectare. This indicates the potential of soils to sequester carbon and in so doing assist in the mitigating of climate change. Plate 5 indicates a topsoil which is rich in organic matter.

CONCLUSION

Agriculture is carried out in intimate association with the environment and therefore has the ability to influence it both negatively and positively. Present agricultural practices in the Caribbean have not been friendly to the environment and so practices which reduce harm to the environment are desired. In this regard, sustainable agricultural practices, because they are designed to work with natural ecological systems are more favoured.

The thrust towards sustainable agricultural systems in agriculture, however, cannot be achieved without the requisite policy framework. This policy must be guided by a new paradigm in agriculture production in the region. This paradigm must be premised on the development of an agricultural production base in each country that seeks to produce upwards of 50% of the country's food needs utilising more locally available resources and indigenous knowledge. This paradigm must be the basis of our food security and food sovereignty agenda under a changing climate scenario.

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The aim of CARDI Review is to highlight quality research by scientists working or collaborating with CARDI, or any other scientist wishing to publish quality work done in the CARICOM region.

CARDI Review publishes research and review papers on production, pest and diseases, germplasm (development, characterisation, production), post-harvest, marketing and agri-business. Papers dealing with the following commodities are especially welcomed:

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ACKNOWLEDGEMENTS

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