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Punta Cana, Dominican Republic, 24 October, 2012

GEF REPCar Final Project Report

**“Improving the Management of Agricultural Pesticides in Colombia, Costa Rica and Nicaragua”
Experiences of the GEF- Reducing Pesticide Run-off to the Caribbean Sea Project**

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IMPROVING THE MANAGEMENT OF AGRICULTURAL PESTICIDES IN COLOMBIA, COSTA RICA AND NICARAGUA

EXPERIENCES OF THE GEF-REDUCING PESTICIDE RUN-OFF TO THE CARIBBEAN SEA PROJECT

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Foreword

When the Land Based Sources of Marine Pollution (LBS) Protocol of the Cartagena Convention was adopted in Aruba in 1999, it confirmed the commitment of Governments of the Wider Caribbean Region to protect their fragile coastal and marine resources from land based sources of pollution. The LBS Protocol committed regional Governments to develop and adopt Best Management Practices to reduce non-point sources of pollution, including from inappropriate agricultural practices.

The GEF-Reducing Pesticides Runoff to the Caribbean Sea (REPCar) Project contributed directly to improving the quality of the coastal and marine environment of the Wider Caribbean, thus supporting the overall objective of the Cartagena Convention – the only regionally binding legal framework for the protection and sustainable development of the Caribbean Sea. The successful testing of new and innovative practices by farmers for reducing the use and run-off of pesticides; the strengthening of national laboratory capacities to conduct environmental monitoring; and improvements in national institutional, legal and policy frameworks has now set the stage for those beneficiary countries to proceed with ratification and implementation of the LBS Protocol which entered into force in August 2010.

The GEF-REPCar Project links agricultural activity and conservation of the environment in a geographic zone where the participation of agricultural production is a major contribution to the economy. This production also directly influences food security and the conservation of coastal ecosystems which are important to the social and economic development of the Caribbean. From the intense inter-institutional work done to connect official environmental and agricultural institutions with research institutions, farmers associations and private sector companies, the project demonstrated that simultaneous benefits for the farming industry and the environment can be generated.

Likewise, by promoting and strengthening the links between research centres and farmers it was demonstrated through projects on Good Agricultural Practices that it was possible to introduce new techniques to which the farmers were previously resistant to adopt. In this way, the feasibility of Good Agricultural Practices was confirmed and these projects became the means through which dissemination and training programmes continued after project closure.

Parallel to the challenges undertaken and the work done, it is important to highlight the high quality work of persons who collaborated with the project and made the work gratifying. With their motivation and commitment to environmental protection and sustainable development as common denominators, this group of persons from different countries, with different background and experiences, as well as different perspectives, has definitely enriched the discussions and the decision-making process, thus positively influencing the successes achieved under the GEF-REPCar Project.

Sign

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Preface

The Colombia Costa Rica and Nicaragua GEF Project: Reducing Pesticide Runoff to the Caribbean Sea (REPCar) is an agro-environmental initiative particularly aimed at mitigating the degradation of the coastal and marine environment in the Wider Caribbean Region caused by pesticides in agriculture. REPCar is funded by the Global Environment Facility (GEF) and is under the Chemicals and International Waters focal area strategies. GEF-REPCar's execution is coordinated by the United National Environment Programme Regional Coordination Unit for the Caribbean (UNEP-CAR/RCU). The Cartagena Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region, and specifically the Protocol Concerning Pollution from Land-Based Sources and Activities (LBS), serves as the framework for this project.

During project execution, the participating countries received assistance for the development and implementation of good management practices and specific measures to control pesticide use in agriculture. Parallel work included the acquisition of reliable data on the use of pesticides and their impact on the environment. The GEF-REPCar initiative was based on four components, where each country undertook activities according to their actual needs and priorities.

The pesticide residue monitoring component was the responsibility of specialised research centres which designed and implemented a monitoring plan to produce a baseline for the presence of pesticide residues in coastal environments in the south-western Caribbean. The development and validation of new agricultural practices using less pesticides were the foundation of the second component. For the execution of this component, a series of crops and specific areas were prioritized, lead agencies committed to sustainable production were selected, and small growers received assistance. The training and outreach component was fundamental to ensure the implementation of new practices among a large number of growers and to share and disseminate project outcomes. Work also included promoting the implementation of national legal frameworks and the introduction of voluntary environmental certification systems for agricultural production at the national level.

Project coordination was the responsibility of each Ministry of Environment working together with their respective Ministry of Agriculture. The needs and priorities identified at the beginning of the project were analysed and discussed within the National Coordination Committees (NCC), which brings together pesticide management stakeholders including growers' associations, ministries, agrochemicals distributors, NGOs, environmental research centres and universities.

This publication summarises the overall results and lessons learned from the GEF-REPCar project regionally. For the reader who wants to have a quick appraisal of the project, reading the final chapter on Conclusions and Recommendations is recommended.

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1. Introduction

Agriculture is of utmost economic importance for the south-western Meso-American Caribbean, especially Colombia, Costa Rica and Nicaragua, where monoculture is intensive. Subsistence agriculture is also quite common, where small growers produce crops such as grains and vegetables for auto-consumption.

In 2009, the harvested area for permanent and temporary crops in Colombia exceeded 3,967,594 ha (MADR 2009). The harvested area in Costa Rica was 472,221 ha (SEPSA 2010) and approximately 800,000 ha in Nicaragua (MAG-FOR 2010). The contribution of the farming sector (agriculture, forestry and fisheries) to the Gross Domestic Product (GDP) of Colombia in 2009 was 8.5% (MADR 2010); 6.7% for Costa Rica (SEPSA 2010); and 19.8% for Nicaragua (ECLAC 2010).

Since the green revolution, the use of pesticides for the control of insects, fungi, bacteria and weeds has intensified to the point where, currently, the productivity of global harvests depend on the application of phytosanitary products to a large extent. Although very useful, these products are also a hazard to the environment and human health. The Caribbean region has been no exception, and high production indices basically result from the ongoing and sustained use of agrochemicals, as reflected in the importation figures (commercial volumes) of these products between 2004 and 2009. An overall rising trend is seen in Colombia and Costa Rica over these years (Fig. 1), while Nicaragua shows a significant reduction over two periods (2006 and 2008).

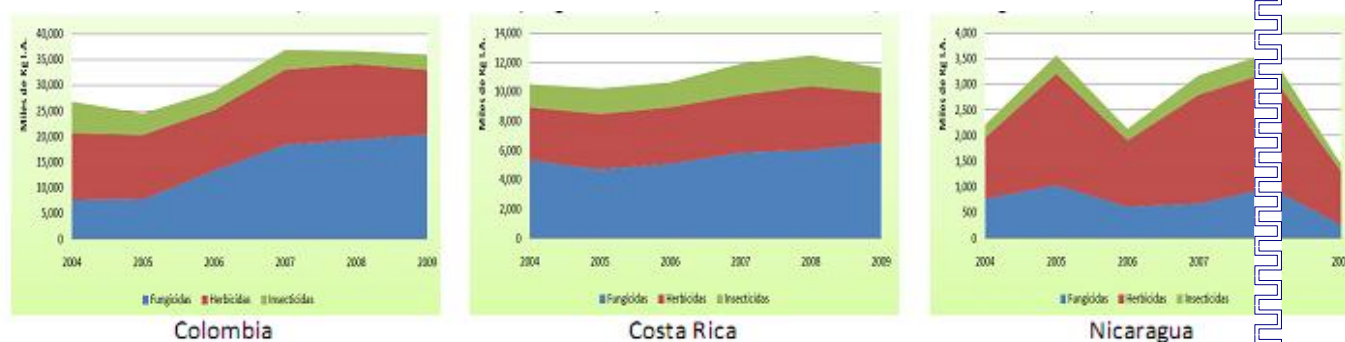


Figure 1. Yearly pesticide imports into Colombia, Costa Rica and Nicaragua (tons of active ingredients of Fungicides (blue), Herbicides (red) and Insecticides (green)) for the 2004-2009 period.

A thriving agrochemicals industry in Colombia includes the synthesization of active ingredients and pesticides formulation, but in order to do this, the importation of raw materials is necessary. Costa Rica and Nicaragua only have a formulation industry. The statistics of Fig.1 reflect overall imports and not national consumption. Imported or locally-produced agrochemicals, like in Colombia, may be consumed locally or formulated for export to countries in the region. In Costa Rica, Ramírez (2009) estimated that pesticide exports represented 20 to 25% of the total products imported.

Fungicides are the most imported pesticide-type into Colombia and Costa Rica, followed by herbicides and insecticides. National reports indicate that Mancozeb,

used by growers to combat fungi on multiple crops, is the most imported pesticide into these two countries. **Herbicides are most commonly imported into Nicaragua**, followed by fungicides and insecticides. The most demanded active ingredient is the 2.4-D herbicide.

High levels of agrochemicals application in agriculture can cause severe soil and water contamination, mostly due to surface runoff and percolation into ground water, which eventually reaches coastal areas. **The presence of these contaminants alters coastal and marine ecosystems and jeopardizes the economies of countries that heavily rely on tourism and fisheries.** Marine ecosystems, especially coral reefs, are extremely fragile and susceptible to contamination from toxic substances, to changes in temperature and acidity, and to reductions in dissolved oxygen levels. Needless to mention, these ecosystems are very attractive for fishing and underwater tourism, and they function as natural barriers that protect the land from tide surges. At the same time contribute to the formation of beautiful white-sand beaches.

According to a study by the World Resources Institute (2005), almost two thirds of the coral reefs in the Caribbean region are directly threatened by human activity, and economic losses are estimated to be between US\$350 and US\$870 million per year. Continuous discharges of sediment, nutrients and toxic substances into water bodies foster the development of algae and pathogens, reduce light penetration, inhibit photosynthesis, accelerate decomposition and consume dissolved oxygen, turning these waters into a hypoxic habitat, not very suitable for the species that live there.

Sedimentation in rivers and oceans is usually related to deforestation, agricultural expansion, cattle grazing or unplanned urban growth, gradually displacing natural ecosystems. Additionally, atmospheric phenomena like hurricanes have negative or even devastating effects on these resources.

In this context, the GEF-REPCar project sought to reduce the impacts of intensive agricultural activity in the Caribbean region that threaten our ecosystems, by implementing good agricultural practices in each of the countries involved. The GEF-REPCar initiative was based on four inter-related thematic areas in which each country developed activities according to its needs and priorities:



Pesticide Residues Monitoring

Under this component, Colombia, Costa Rica and Nicaragua established a baseline with information on pesticide residues in coastal areas for the 2008–2010 period. With the support of GEF-REPCar, the countries were able to strengthen their analytic capacity to detect more pesticide molecules and share and validate analytical methodologies. To

add to this component, statistics on apparent agrochemicals consumption (importation and/or production) were updated in each country up to 2009. This information is of very high interest to the countries as it evidences the elevated importations of agricultural inputs and obligates players to take stronger measures to regulate usage.

Development and Validation of Innovative Agricultural Practices to Reduce Pesticides Use

Within this framework, a series of demonstration projects that validated new technologies related to the phytosanitary management of different crops (rice, bananas, beans, oil palm, pineapple, plantain) were executed with the expectation of a substantial reduction in pesticide runoff to coastal areas. This component also included quantification of environmental, social and economic impacts resulting from changes in traditional agricultural practices.

Training and Outreach

Diverse training and awareness programmes were developed for growers, agricultural technicians and owners of agrochemicals distribution centres, and focused on good agricultural practices, integrated pest management and adequate pesticide use and handling. The results from executing these components were shared through training sessions and lessons learned workshops with local farmers, as well as through national and regional scientific and awareness raising events. Printed materials were distributed at these events and electronic versions of same are also available on the project's web site.

Incentives, Legal Frameworks and Control

The GEF-REPCar participating countries have important pesticide-related legal frameworks but limited enforcement mechanisms. The project supported the compilation and dissemination of existing legislation and encouraged national GAP crop certification programmes at the national level.

2. Impact of pesticides-use on the quality of coastal waters

To identify and quantify the presence of traces of pesticides in the Caribbean coastal waters of Colombia, Costa Rica and Nicaragua, a coastal monitoring programme was developed and 7 sampling campaigns were scheduled for the 2008-2010 period with samples coming from 64 locations (Figure 2). The campaigns included the rainy and dry seasons.

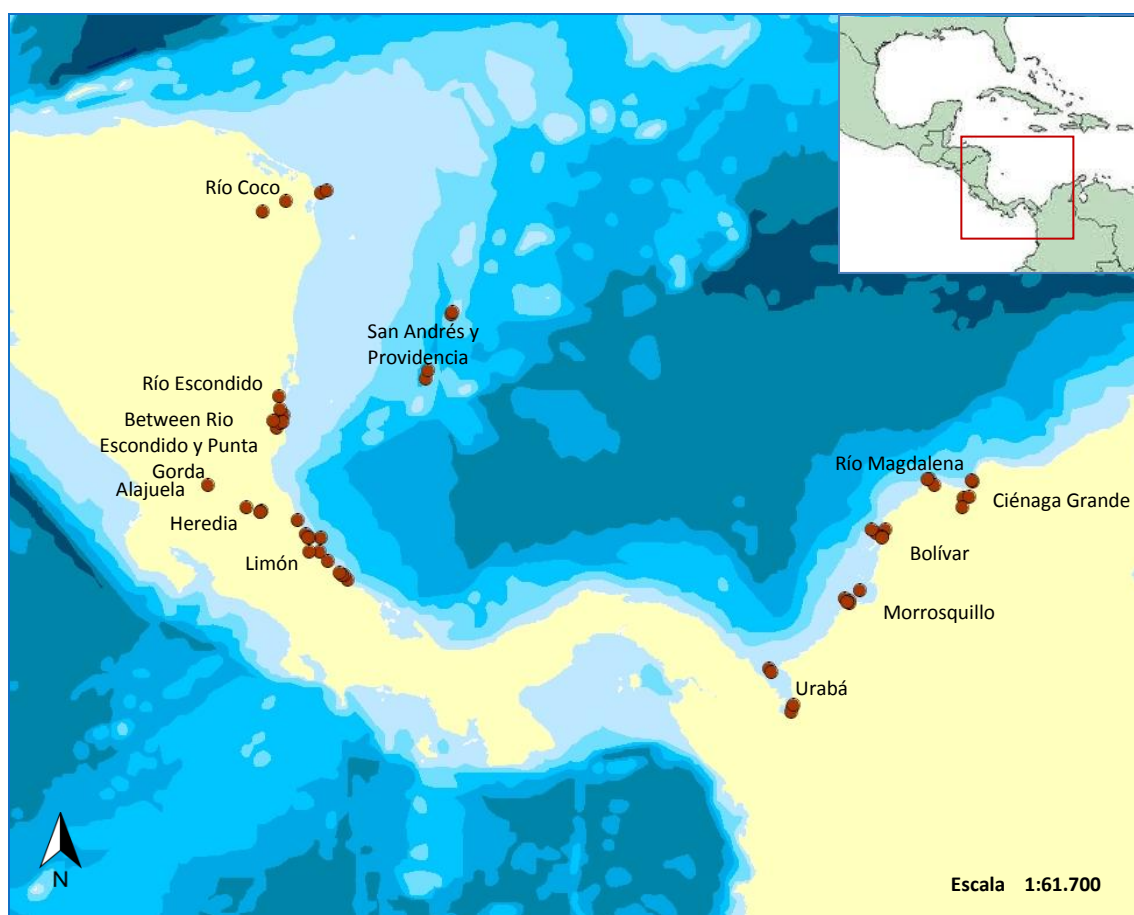
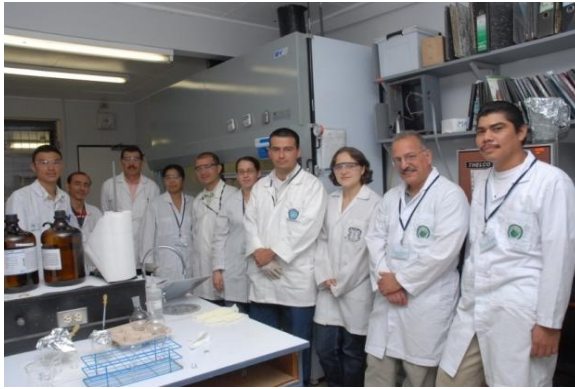


Figure 2. Distribution of sampling stations of the coastal monitoring programme for 2008-2010

During the monitoring process, samples of water and sediment were collected and analysed. Additionally, samples of oysters were collected to determine the presence of pesticides in their tissue and passive samplers were used at some of the points of interest.

A specific group of pesticides (active ingredients) and their metabolites were monitored during this study, using the most applied phytosanitary products in the three countries as its basis, with the exception of Glyphosate, Paraquat and Mancozeb. These were excluded since some of them degrade rapidly in the environment or require a very complex analytical procedure for their detection and quantification, rendering their quantification difficult. In total, 41 compounds were selected for monitoring.



The coastal monitoring programme was executed by centres of excellence in environmental studies in the region: the Institute of Marine and Coastal Research of Colombia (INVEMAR), the Centre for the Research in Environmental Pollution and the Centre for Marine and Limnology Research of the University of Costa Rica (CICA-CIMAR/UCR),

and Aquatic Resources Research Centre at the National Autonomous University of Nicaragua (CIRA/UNAN). These Centres, complemented by external experts, constituted the advisory panel which guided the programme in all technical and scientific aspects, including the design of the monitoring programme and activities for strengthening the analytic capacities of the participating institutes.

2.1 Detection and quantification of pesticides in the coastal environment of the region

In the water samples analysed, only 1.9% of the total number of tests for different pesticides showed quantifiable concentrations, while the presence of residues was not detected in 95.3% of the cases (Figure 3A). The behaviour in sediments was very similar; 93.1% did not show the presence of pesticides and only 3.8% showed quantifiable values (Figure 3B).

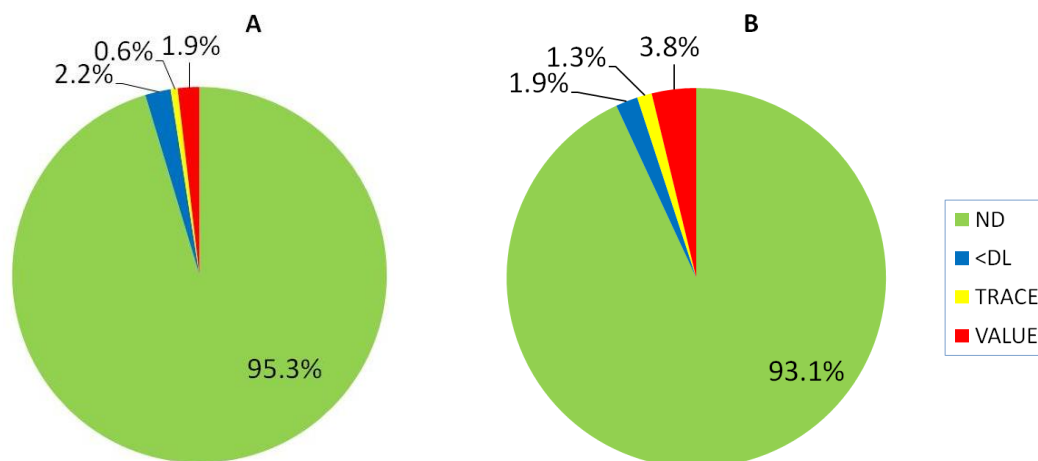



Figure 3. Distribution of analytical results according to detection level in water (A) and sediment (B) samples collected at all stations in Colombia, Costa Rica and Nicaragua. Quantifiable levels (VALUE), not quantifiable more than the limit of detection and less than the limit of quantification (TRACE), below the limit of detection (<LD), not detected (ND).



In water samples collected, 28 molecules could be quantified along the Caribbean coast of Colombia, Costa Rica and Nicaragua. The pesticides most frequently found were: Dieldrin, Lindane, Endosulfan I and Diuron (Figure 4).

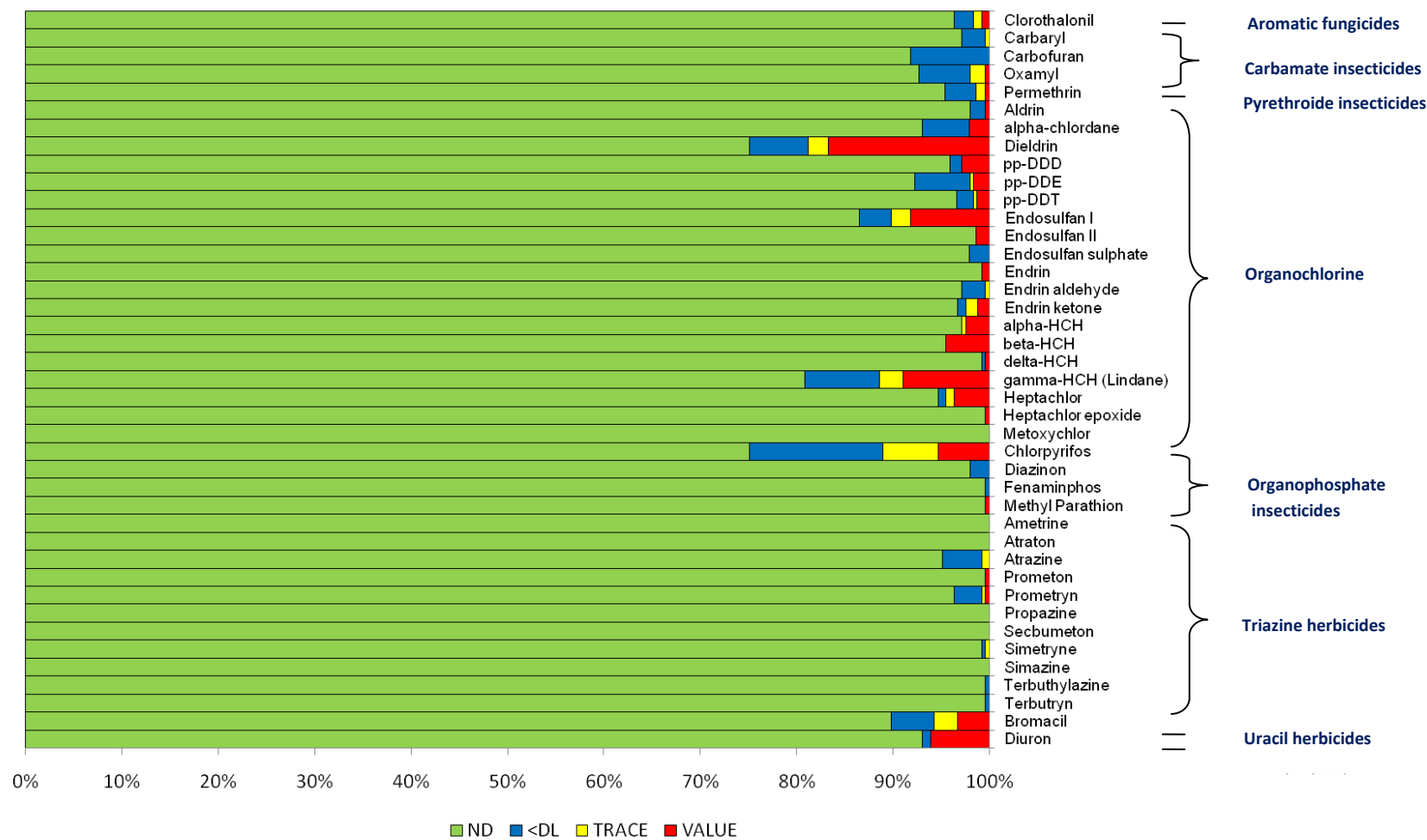


Figure 4. Distribution of analytical results according to detection level for pesticide compounds in water samples collected at all sampling stations in Colombia, Costa Rica and Nicaragua. Quantifiable levels (VALUE), not quantifiable above the limit of detection and less than the limit of quantification (TRACE), below the limit of detection (<LD), not detected (ND).



In the case of sediments, which by their physical-chemical characteristics attract more pesticides, 31 molecules were quantified. The pesticides found more frequently above their respective quantification limits were Chlorpyrifos, Lindane, and Endosulfan and their metabolites (Figure 5). In addition to what was considered in figures 4 and 5, the presence of other pesticides was assessed based on the interest of each country. Only Fenbuconazole and Triadimefon showed values in water; and Cypermethrine, Fenbuconazole and Difeconazole and some organophosphates in sediments.

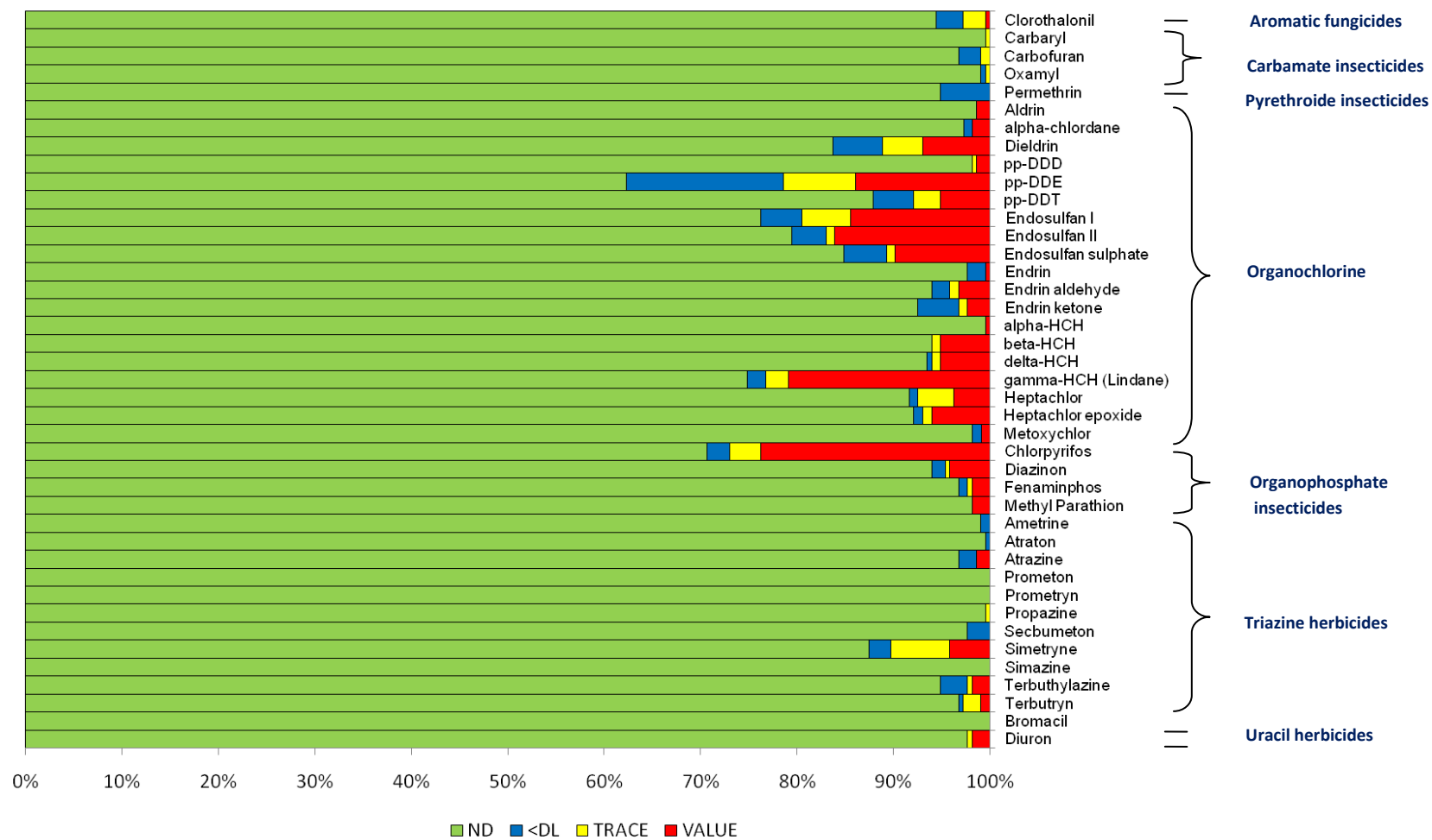


Figure 5. Distribution of analytical results according to detection level for pesticide compounds in sediment samples collected at all sampling stations in Colombia, Costa Rica and Nicaragua. Quantifiable levels (VALUE), not quantifiable above the limit of detection and less than the limit of quantification (TRACE), below the limit of detection (<LD), not detected (ND).



A high percentage of the pesticides detected in water and sediment samples were persistent organic pollutants (POPs), such as Heptachlor, the group of chlorines or the metabolites of DDT, among others. Their use has been prohibited in the region since the '70s and '80s. Despite this and due to their persistent nature they can still be detected in environmental samples. Lindane and Endosulfan, which were also found during the regional monitoring, were recently included in Annex A of the Stockholm Convention, hence, the countries which still apply them are preparing to use substitute their use.

There are no reference values for specific pesticides in the region, therefore the SQuiRTs manuals (Buchman, 2008) prepared by the NOAA (National Oceanic and Atmospheric Administration, of the USA) are used to carry out the evaluation of the results. These manuals are based on information from the US EPA (US Environmental Protection Agency), and regulations from other countries such as Canada and the Netherlands. The limits indicate different levels of protection for aquatic life.

Most of the concentrations of pesticides detected in waters were relatively low. Higher values were observed for products that are currently found on the market, namely Endosulfan I, Chlorpyrifos or Diuron, although significant concentrations of Lindane and Dieldrin (POPs) were also found. In the majority of the cases, they did not exceed the reference values of the SQuiRTs manuals. The availability of reference values for specific pesticides is less in sediment than in water, and only information for POPs is reported. It is important to point out that many of the POPs found exceeded the PEL limit (probable effects limit on aquatic organisms) established in the SQuiRTs manuals.

In the **oyster samples** analysed in Nicaragua, no pesticides residues were reported. However, practically the same compounds found in water and sediment were detected, as well as some others, were detected in the **passive samplers** that were used in Costa Rica.



It was observed that the results obtained were influenced by meteorological phenomena such as “El Nino” in 2009 and “La Nina” in 2010. The reduction or the increase in the intensity of rains can cause extreme situations, such as the runoff of pesticides residue from the upper parts of watersheds (agricultural fields) to the coastal

marine area. The processes of dilution in the rivers also alter the levels found.

The presence of pesticide residues in multiple points along the coastal zone indicates run-off from the agricultural field to marine ecosystems. The frequency

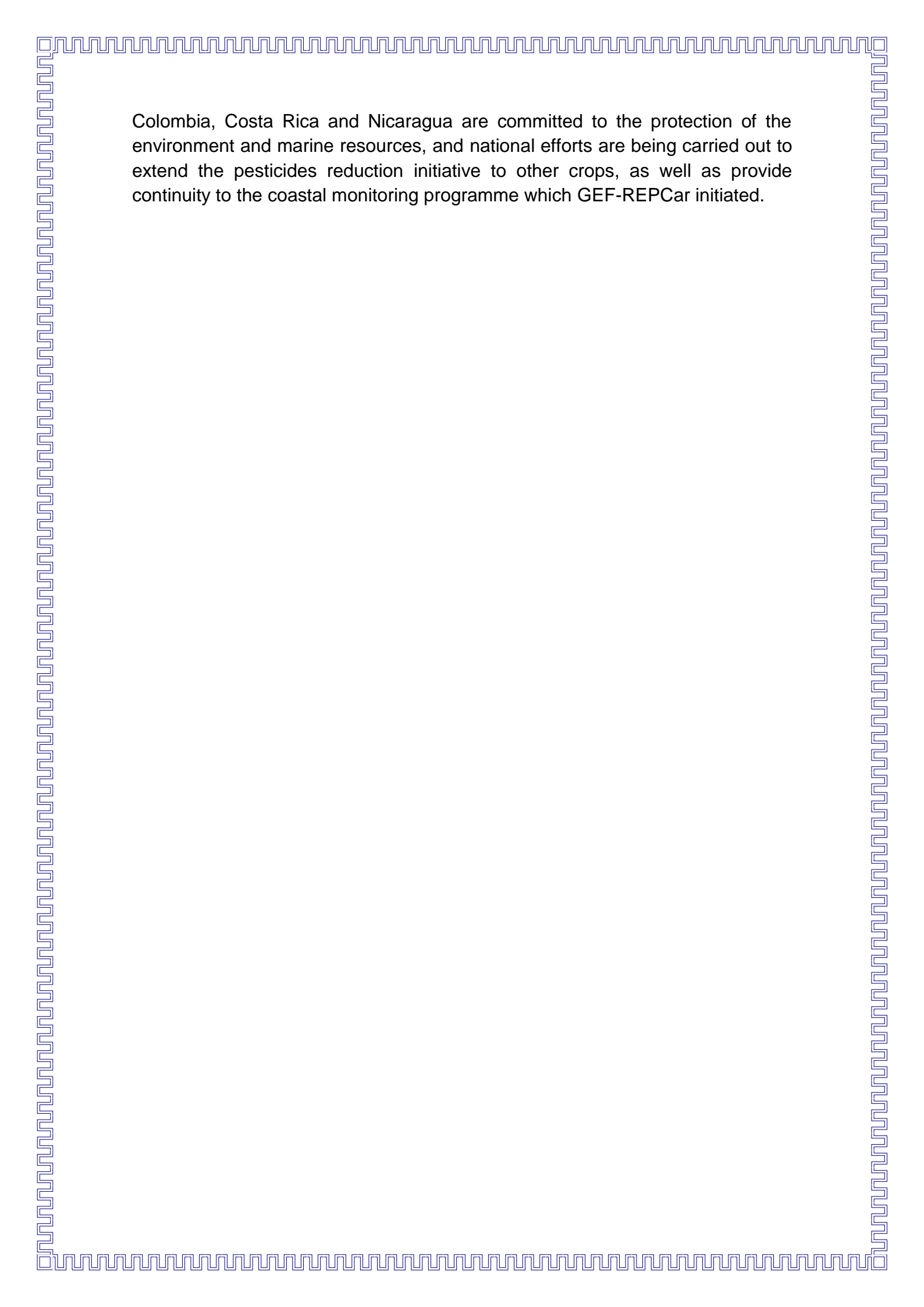
and low concentrations of some of the molecules detected clearly do not pose immediate danger to health or the environment, but is a warning that should be heeded.

Some of the pesticides that were detected are part of the phytosanitary management practices applied in monocultures such as pineapple, banana, plantain or oil palm. These are also used on many other crops which form part of the production basket of small producers. Both the large and the small farmers do not always have the knowledge and the appropriate technology, which allow them to carry out adequate crop management practices, therefore the effects of their practices can affect the quality of the coastal marine environment. The metabolites of DDT found can also be related to the DDT used in the past to control vector diseases like malaria.

The monitoring programme was instrumental in improving the technical capacities of the participating institutions. The baseline generated very useful information, for each of the countries, on the types and concentrations of pesticides in their coastal waters, but it is only the beginning of a medium- to long-term work. Based on the results obtained to date, it is recommended that economic resources be allocated to provide continuity to the monitoring of pesticide residues in water bodies of the region, as well as extend the study to other areas at risk. To achieve this objective, it is important to continue strengthening the cooperation frameworks between the private sector, represented by the producers and users of agrochemicals products, as well as environmental research institutes and governments.

The monitoring results were reported to the stakeholders involved in the pesticides chain in each country and were discussed at length by GEF-REPCar's National Coordination Committees. The public and private sectors participated actively on these committees. The information generated is an important input for the development of new policies and for improving the practices in the field.



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Colombia, Costa Rica and Nicaragua are committed to the protection of the environment and marine resources, and national efforts are being carried out to extend the pesticides reduction initiative to other crops, as well as provide continuity to the coastal monitoring programme which GEF-REPCar initiated.

3. Innovations in the agricultural sector to reduce the use of pesticides: Demonstration Projects on Good Agricultural Practices

3.1 Introduction



The present market requirements for agricultural products have encouraged the development of new technologies at the national and international levels aimed at a more sustainable agricultural production, where the quality and the safety of the produce, the protection of the worker in the field and the environment are guaranteed. This

improvement to the traditional production systems known as “good agricultural practices – GAP”, is well used in international markets and is consistent with the objectives of the GEF-REPCar Project. The Project focused much of its efforts on the introduction and promotion of GAP, combining integrated pest management practices with the reduced use of agricultural pesticides.

Due to the risk involved in carrying out a change in the method of production, good agricultural practices adopted by the producers vary. The farmers must secure their harvest, and the use of agrochemicals in a preventative way has been one of their allies, especially in intensive cultivation. The uncertainty of production cost is a barrier to the implementation of integrated management practices with a reduction in the use of synthetic pesticides. These factors make it difficult for the farmers to implement the recommendations made by the research centres. There are also the experiences of farmers in alternative management practices, which are very valuable and must be taken into account when proposing practical alternatives for the control of pests. In many cases, these experiences have not been formally evaluated, making their promotion and adoption by a larger group of producers difficult.

GEF-REPCar’s demonstration projects were instrumental in closing the gap between advances in research and their application at the commercial level, through the implementation and evaluation of innovative management practices to reduce the use of pesticides on farms. The practices assessed are good agricultural practices and best management practices for pesticides. At the first stage, the National Coordination Committees of the GEF-REPCar project carried out a prioritization of the crops being studied, based on the pesticides application indices and their proximity to the coastal areas. The implementing agencies for the demonstration projects were selected, and links with the

productive sector and with entities specializing in agricultural and environmental research were established.

According to crop conditions, the goals for the reduction of pesticide use in each project were defined. **The projects assessed the impact of the new practices on the economic return, pesticides run-off to water bodies, and the potential risks to human health (exposure) resulting from their implementation.** Figure 6 shows the locations of the beans and rice demonstration projects (RAAN, Nicaragua) and oil palm (RAAS, Nicaragua); pineapple and banana (Costa Rica), and plantain and banana (Urabá and Magdalena, Colombia). Similarly, the projects developed several dissemination and training activities which were aimed at producers, agricultural technicians and the rural community.

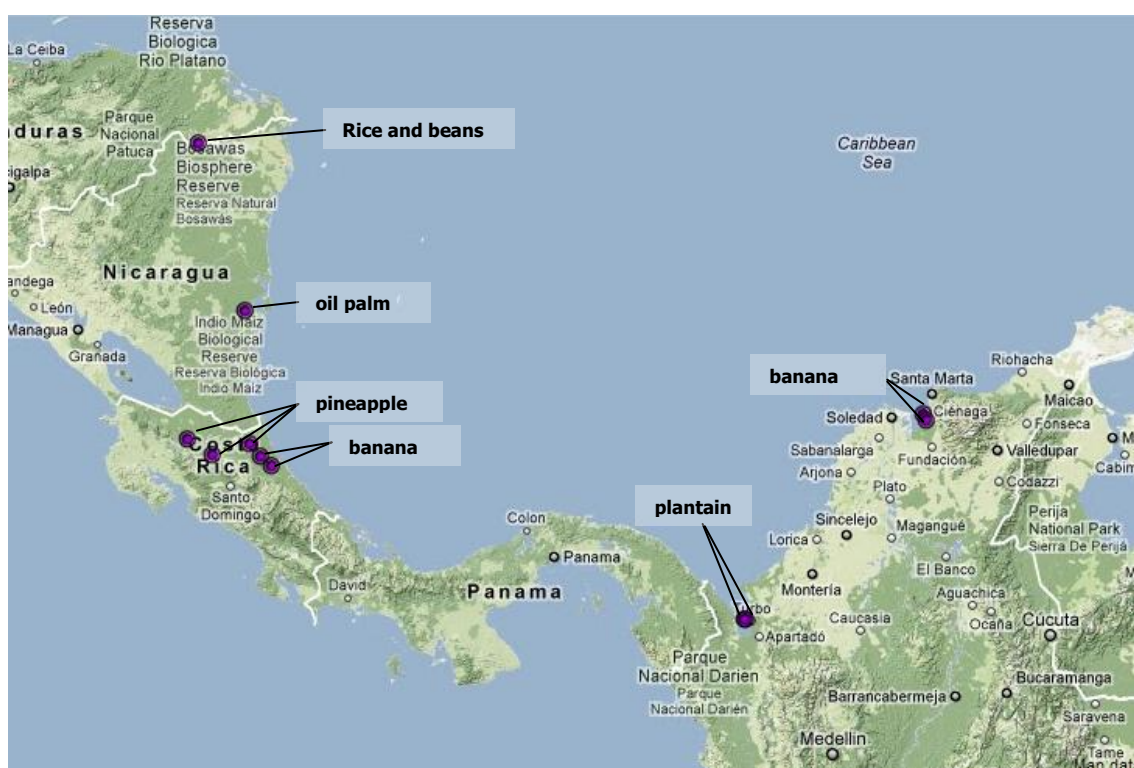


Figure 6. Distribution of the GAP demonstration farms of GEF-REPCar. In the case of beans and rice, and oil palm, demo plots in various communities were established in the area of influence.

Case Studies

The GAP demonstration projects were designed in accordance with the characteristics and requirements of the different crops selected in Colombia, Costa Rica and Nicaragua. These projects accumulated a valuable series of experiences that can be the basis for similar initiatives.

For the prioritization of the crops and areas of work, the use of agrochemicals per hectare, the cultivation area, environmental problem (risks of run-off), the proximity to the Caribbean Sea, the potential risks to health and the social context of the rural population were considered. This last factor has been especially relevant in the bean project in Nicaragua, where the lack of training and technical assistance in the region constitutes a significant risk for the health of the farmers, their families and the coastal ecosystems. In this way, GEF-REPCar included a variety of different conditions with crops on a large scale (pineapple and banana in Costa Rica), crops on a small scale (banana and plantain in Colombia, oil palm in Nicaragua) and subsistence crops (beans in Nicaragua).



The success of the demonstration projects is the result of continuous inter-institutional coordination among government entities, as well as the productive sector, universities and UNEP, regarding the subject of pesticides management. At each demonstration project and for each crop, the empowerment of the different stakeholders and the strategic alliances established with

professional associations and research centres were key in achieving the objectives. Despite having a common goal, the strategies developed by the projects were adapted to each situation. These were prepared by national experts, and contributed to the sustainability of activities, fostering the development of local capacities without involving international consultants.

The implementation of best management practices required a set of measures: **improvement of existing infrastructure** (banana and plantain post-harvest areas and in Colombia); **the introduction of technological tools** (introduction of certified seed in beans, the use of plastic soil covering for large-scale pineapple production, the introduction of biological control in oil palm in Nicaragua, in pineapple and banana in Costa Rica and banana and plantain in Colombia); and the **adaptation of crop management practices, with emphasis on integrated pest management tools**. The latter entails utilizing physical, biological and chemical tools which are applied depending on the results of the monitoring of pests.

The technical and scientific validation of the different innovative practices brought about a significant reduction in the use of synthetic pesticides on pineapple and banana demonstration crops in Costa Rica, banana and plantain in Colombia and beans and oil palm in Nicaragua. The reductions fluctuated depending on the sanitary problem of the crop; in Costa Rica, for

example, the reduction was 35% of active ingredient in the intensive cultivation of pineapple and 8% in the cultivation of banana, where there was significant experience in the implementation of GAP prior to the project.

The demonstration projects showed a reduction in the presence of pesticide residues in water bodies, but given the complex dynamics of the degradation and mobility of these molecules in the environment, it is not easy to establish a direct cause-effect relationship. On the banana and plantain farms in Colombia, the GAPs and improvements made to the infrastructure contributed to a significant difference in the concentrations of contaminants found in the first and last environmental samplings.

For the farmers, it is essential that the implementation of good agricultural practices (GAP) or integrated pest management (IPM) does not negatively impact production costs. On a smaller scale, as is the case of the small producers of pineapple in Costa Rica and banana and plantain in Colombia, a lower investment was required to carry out improvements in the established capacities to be able to adopt new practices. This made the adjusted production system more competitive from an economic perspective.

For the cultivation of subsistence crops, as is the case of beans and rice in the RAAN in Nicaragua, it is not easy to positively impact on the farmers' income since over the years and for various reasons, they have not had the conditions necessary for carrying out proper agricultural and sanitary management practices. **The implementation of GAP and IPM requires an economic effort, but the benefit for health and the environment compensates, to a large extent, for the investment costs.**

The initial investment which led to the introduction of new management strategies is important in intensive and large-scale crops such as banana in Costa Rica where the increase in productivity does not always cover the increase in production costs in the short-term. In the case of pineapple, BANACOL in Costa Rica reduced production costs and was successful in increasing their profits as a result of the implementation of GAP and IPM.

The results derived from the experiences acquired during the execution of the demonstration projects were shared with producers through the training and awareness component. In Colombia, 786 persons were trained through direct technical assistance on the farms and 3,424 persons participated in different training events, among which were producers, technicians and agricultural workers. In Costa Rica and Nicaragua, participation was 1,497 and 508 persons respectively.

3.2 Good Agricultural Practices for the cultivation of banana in Costa Rica – Corporación Bananera Nacional (CORBANA)

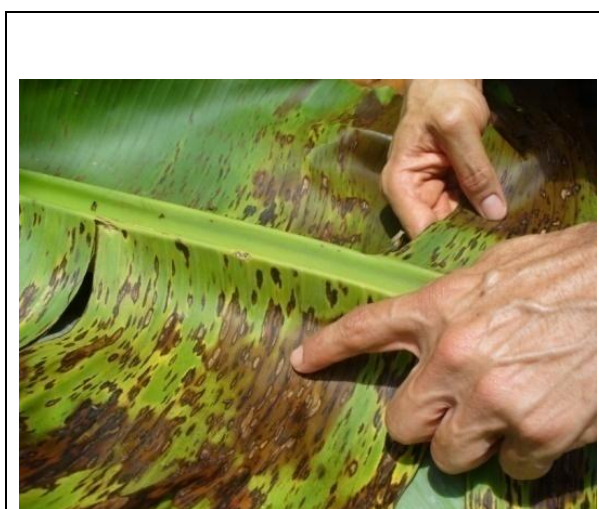


Banana crop in Costa Rica.

At present, Costa Rica is one of the principal banana producers in the world with an average of 2,303 boxes per hectare (42 metric tons) per year, one of the highest productivities at the international level. This productivity, in relation to an area of 43,031 hectares, allows Costa Rica to reach a total production of nearly 100 million boxes and earn US\$728.7 million for 2010. Additionally, the banana industry is the principal source of employment in the Caribbean region of Costa Rica,

providing around 40,000 direct and 100,000 indirect jobs. For Costa Rican companies, the banana farms have an average area of 269 ha (CORBANA 2011). The banana producers have made great efforts to implement Good Agricultural Practices in their production systems since the 90s, when the first agricultural and environmental certifications were received.

Owing to the application regime of agro-chemicals during the production and post-harvest stages, the flat topography and high volume of rainfall experienced by the Caribbean region, it is necessary to complement the traditional production strategy with additional measures which prevent the runoff of agrochemicals into water bodies. In addition to the good agricultural practices already implemented, CORBANA developed and validated a series of innovative management practices, and this combination is now classified as “Good Agricultural Practices plus” (GAP+).



Banana leaf affected by Black Sigatoka

The GAP+ system was based on the implementation of two strategies: reduction in the levels of pesticides application and the application of different practices to reduce the runoff of the pesticides that were used.

a. Participating entities

The demonstration project was implemented by CORBANA's Research Division which is responsible for developing the research required by the banana industry in order to maintain the highest productive indices. The project was executed on two banana farms: the first (eastern farm region) located to the east of the Reventazon river of about 261 hectares, and the second (western farm region), of 388 hectares (Fig. 7). Two demonstration plots were established on each farm, one with conventional management and the other with alternative management practices (GAP+). The average area assigned for the different demo plots with different management practices was 5 hectares.

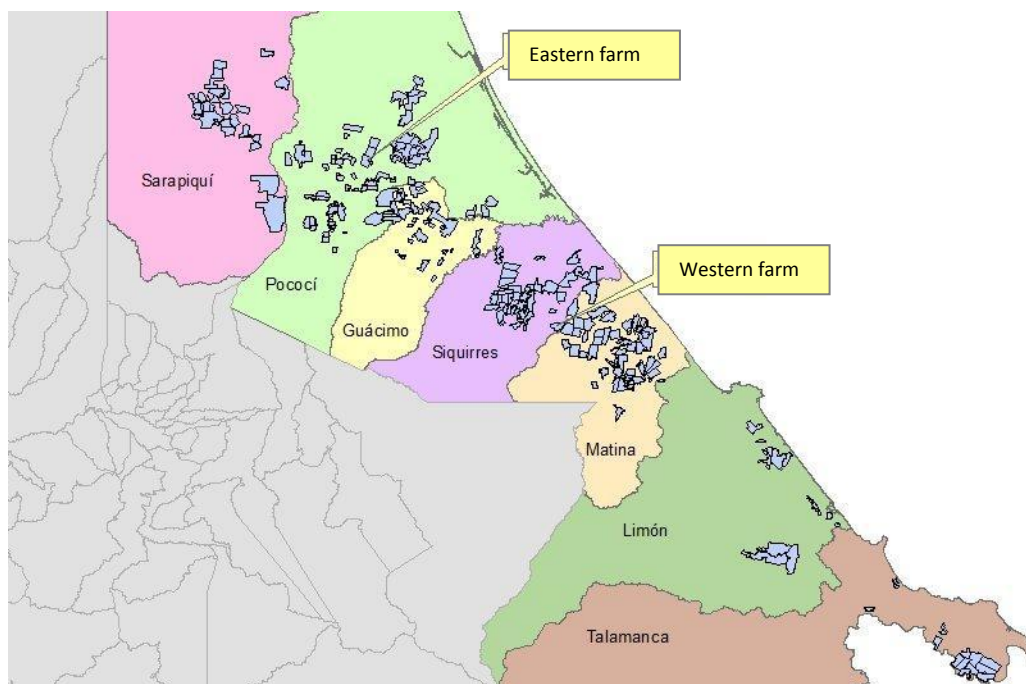


Figure 7. Distribution of banana farms to the east and west of Rio Revetazon in Costa Rica

b. Validated technologies

For the agrochemicals reduction strategy, the monitoring and assessment of applications, the use of preventative practices (crop cleaning, the early pocketing of bunches), the substitution of pesticides applications by biological control agents, and alternative substances of low toxicological profile were considered. The reduction in pesticides use established on the plots with GAP+ was 4.95 kg active ingredient (a.i.) per ha



Management of drainage Canals with vegetation to reduce erosion and runoff.

per year, corresponding to 7.63 % of the total amount applied. This reduction included the elimination of a cycle of nematicides (33% of the total amount), and the total elimination of the use of herbicides (Table 1). A reduction in the quantity of fungicides used was not considered due to the fact that in addition to the aggressiveness of the pathogen, the applications for the control of Black Sigatoka were carried out aerially and the demonstration plots were located on commercial estates. Additionally, the use of synthetic fertilizers was reduced by 25%; therefore crop nutrition was supplemented by organic sources, with the consequent environmental and economic benefits.

In applying different practices to reduce pesticides runoff, the incorporation of nematicides into the soil through the forking technique or their injection into the pseudostem, the establishment of buffer areas and the planting of vegetation on the plantation and in drainage canals, were validated. Additionally, with the objective of giving the productive system greater sustainability, an overall improvement of soil and root health was encouraged through the application of nitrogenated sources with low acidifying effect, of limestone and of organic matter colonized by useful micro-organisms.

Table 1. Reduction in pesticides use (kg a.i./ha/year) achieved on the demonstration plots with GAP+, compared to the plots with conventional management.

Pesticide	Quantity (kg a.i./ha/year)		Reduction
	Conventional Practice	Alternative Practice GAP+	Kg a. i./ha/year
Fungicide	53.89	53.89	0.00
Nematicide	8.81	5.87	2.94
Herbicide	2.01	0.00	2.01
Insecticide	0.18	0.18	0.0
Total	64.89	59.94	4.95

According to the calculations done, if the reduction of 4.95 kg a.i./ha/year achieved is applied to the entire cultivation area (about 43.000 hectares), the total saving of active ingredient will be 210,710 kg a.i./ha/year. This would be very significant from an environmental and economic point of view.

The adoption of new practices reduced, on both farms, the use of agrochemicals such as fertilizers, nematicides and herbicides but generated additional costs for labour and some other inputs that were not considered in traditional management practices (Table 2). Productivity on the plots with GAP+ management was similar to what was observed on those with conventional management. For the establishment of new crop management practices, more staff was required during the soil covering phase. This increased the operational costs in the short term, but a reduction is expected in the medium term.



Post-harvest area on banana farm

Table 2: Total production costs associated with the GAP+ and conventional production practices developed on banana farms in the Eastern and Western Region in US\$/ha/year (May 2010 to March 2011)

Farm	Production Costs (US\$/ha/year) and productivity (boxes/ha/year)	
	GAP+ management US\$/ha/year	Conventional management US\$/ha/year
Western Farm Region	13,482 (2752 boxes/ha/year)	11,700 (2763 boxes/ha/year)
Eastern Farm Region	12,080 (2793 boxes/ha/year)	10,401 (2554 boxes/ha/year)

c. Environmental benefits

The results of environmental sampling carried out by the Research Centre for Environmental Pollution (CICA) showed that the pesticides mostly detected in water were the fungicides Epoxiconazole and Tebuconazole, which are applied aerially to fight Black Sigatoka. Also, the presence of Chlorpyrifos and Diazinon was found in water, the first is formulated in the plastic which covers the bunch and the latter is not applied on the crop and could have been present due to derivation processes.



Sample taking from the increased water in drainage canals to test for pesticides residue.

The presence of residues of Terbufos and Cadusafos granular nematicides was also detected in soils. Although Endosulfan had not been applied on banana over the last 30 years, Chlorpyrifos,

Bifenthrin and Endosulfan α and β were detected; therefore their presence could only be explained due to flooding and the depositing of sediments. Finally, Thiabendazole, a fungicide that is used post-harvest to control fungi such as *Colletotrichum musae*, *Thielaviopsis paradoxa* and *Fusarium* spp that affect the crown, was detected in the soft part of the fruit. Bifenthrin and Mancozeb were sporadically detected.

In comparing plots with GAP+ and the plots with traditional management practices, a clear trend in the reduction of the most frequently detected pesticide concentrations was observed. The presence of pesticides was detected in only 16.3% of the total number of the samples analysed. Of this total, 8.0% came from plots with GAP+ and 8.3% from plots with conventional management. 100% of the concentrations detected were way below the maximum limits permitted internationally, which ensures the quality and safety of the product, and motivates the banana sector to continue undertaking efforts to improve their production systems.

d. Sharing of experiences

The experiences gained during the validation of the innovative crop management practices were shared with the banana sector through workshops, seminars and publications (Table 3). In order to assess the adoption level of GAP+ and its potential impact on health, a risk assessment was done for banana workers, based on 19 agricultural tasks. The result showed that the new tasks pose a low level of risk, considered trivial, which means that additional actions for its control are not required.



Training activity in the field.

Table 3. Dissemination of the results and lessons learnt during the implementation of the GAP+ by Corbana

Implementing Agency	Training and Technical Assistance	Published Material
CORBANA banana (Large Producers)	<ul style="list-style-type: none"> • 346 participants (producers and technicians) in GAP trainings • The results of the project were shared with 194 persons who carried out technical consultations at CORBANA 	<ul style="list-style-type: none"> • GAP banana manual • 1 technical video on GAP production of bananas • 8 informative sheets (technical bulletins on specific phytosanitary themes) • 4 informative brochures • 1 poster for general awareness

3.3 Good Agricultural Practices for the banana and plantain cultivation in Colombia – Asociación de Bananeros de Colombia (AUGURA)

Banana cultivation in Colombia has earned an important place in the economic and social context, both at the national and regional level, because of its ability to generate foreign exchange and jobs. Banana is Colombia's third most important crop for exportation, with an area of some 44,500 hectares cultivated in two regions of the Caribbean coast; 33,500 ha in Urabá and 11,000 ha in Magdalena. In 2009, the exports were about 96.7 million boxes of 18.14 kg, with a value of US\$ 705.6 million. As part of this activity some 7,000 direct and 12,000 indirect jobs were generated.

Colombia has an area of approximately 200,000 ha dedicated to plantain cultivation which is distributed over a wide cross-section of the country, and the majority of it is for national consumption. In 2009, an area of about 15,000 ha was dedicated to plantain cultivation in the region of Urabá, and 5.5 million boxes of plantain were exported for a total value of US\$49.6 million. Nearly 10,000 families benefit from the production of plantain for export.



Aerial view of banana crop near to the sea in Urabá, Colombia.

In Magdalena, a high percentage of the small banana farms was certified in good agricultural practices (GlobalGAP), as opposed to Urabá where the majority of the plantain farms are still not certified. These farms were having various problems with the management of agrochemicals: the application of pesticides without a prior assessment of crop conditions, the dumping of pesticide residues from the washing of application equipment and post-harvest waste into water bodies, the improper disposal of solid waste, and the low usage of personal protective gear.

With the development of this work, the Asociación de Bananeros de Colombia (Augura) is trying to mitigate the negative impacts generated by banana and plantain crops in the regions of Magdalena and Urabá, through the validation and demonstration of a series of crop management practices focused on improving the use of pesticides and the reduction of their run-off on 2 banana and 2 plantain farms.

a. Participating entities

The work was carried out by the Asociación de Bananeros de Colombia (AUGURA), along with the staff of the selected demonstration farms. AUGURA is a non-profit civil corporation, an association that unites farmers and international banana marketers from the Urabá region of Antioquia and from Magdalena. The coordination of the

demonstration projects was supported by two of AUGURA's programmes: CENIBANAO and BANATURA.

CENIBANAO is the programme that provides the banana farmers with technological support, allowing them to increase productivity, through the generation of technologies adapted to the local production conditions, which are aimed at cost reduction and at increasing the economic and environmental competitiveness of the Colombian fruit. The BANATURA environmental programme supports the development of sustainable productive practices in the banana industry through a management and social and environmental performance process, which was being executed from the year 2000 in Urabá and from 2005 in Magdalena. This obtained greater commitment of the banana sector to environmental matters.



Rainfall is measured to plan sanitary risk and application as part of Integrated Crop Management.

Participating farms

The implementation and validation of the **GAPs in banana** were carried out on two small farms in the Department of Magdalena, municipality of Zona Bananera.

- **La Josefa 4**, with an area of 3.8 hectares, has drainage canals that dump their waters in a natural channel which flows into the Ciénaga Grande de Santa Marta. This property was already showing significant progress in the implementation of GAP prior to its participation in the project.
- **La Yudis**, with an area of 3.8 ha, has two drainage canals that run cross adjacent farms and flow into the Ciénaga Grande de Santa Marta. The farm employed 'traditional' management practices and was not using GAP at the beginning of the project.

Plantain demonstration projects were implemented on two farms located in the Urabá region of the Department of Antioquia, municipality of Turbo.

- **El Empeño** farm has 3 hectares of cultivated land and has one drainage canal which also collects the water from surrounding farms. This canal then runs through other farms in the sector and finally flows into a natural spring that leads to the Gulf of Urabá which is 5 km away from the property. El Empeño had already made progress in the implementation of GAP prior to the project.
- **The Hermanos Mora** farm has an area of 2.75 hectares of plantain and a central canal that collects the water on the property and flows into a collecting canal that runs across several farms. This canal leads the waters to the Gulf of

Urabá which is located 2 kilometres away from the farm. This farm was not using GAP prior to the project.



(Image taken from Google Maps)

Figure 8. Spatial distribution of the of banana and plantain demonstration projects in Colombia

b. Validated technologies

The project focused on the development and validation of Good Agricultural Practices (GAP) for banana and plantain crops, which is aimed at reducing the use of pesticides through Integrated Pests Management (IPM) and best management practices for pesticides. Labour efficiency, the protection of the environment and the health of farm workers were thus improved. The crop management plan has been documented in the project's publications, which are available on the GEF-REPCar website.



Management of soil covering to eliminate the use of herbicides, reduce erosion and improve soil fertility.

The evaluations on the demonstration farms were complemented by direct assistance that was provided to almost 400 farms and a complete GAP training programme conducted by the Banana Cooperatives, the CORBANACOL social foundation, the BANATURA and CENIBANANA programmes, and GEF-REPCar's staff.

b.1 Good agricultural practices in banana

The strategy applied focused on reducing the use of pesticides when controlling weeds and Black Sigatoka. As a preventative measure, banana bunches were pocketed to protect them from the rays of the sun, in order to improve its weight and the crowns were treated with fungicide solutions through manual sprayings. A new fertilization programme based on soil analysis was implemented and the daily volume of precipitation was monitored to calculate the irrigation needs and thereby reduce possible run-off.

At the infrastructural level, a filtration system was built to treat the pesticide residues generated during product mixing or during the washing of the application equipment and protective gear. In addition, the structural conditions of the agrochemicals storerooms, tools and packaging material, the tanks and tables for washing the fruit, the sanitary services, the shed for the storage of organic and inorganic residues and a canteen for the workers, were improved on both farms.



Infrastructure adaptation of the post-harvest area on a small plantain farm.

With prior experience in GAP, only mechanical control was used for the control of weeds on the **La Josefa 4** farm. On **La Yudis** farm, there was a 100% reduction in herbicides use (Table 4). Vegetative soil covering was introduced and some of the already present weeds were selected; together with proper environmental disposal of harvest residues as physical weed control, and manual control of the more aggressive ones.

Table 4. Reduction in the use of pesticides on La Yudis farm (kg a.i./ha/year) achieved on the demonstration plots with the implementation of GAP for banana, in comparison to the total amount applied on the plots with conventional practice.

Pesticide	Quantity (kg a. i./ha/year)		Reduction
	Conventional Practice (initial)	Alternative Practice (final)	kg a.i./ha/yr
Herbicides			
Glyphosate	4.9	0	4.9
Glufosinate Ammonium	1.92	0	1.92
Foliar Fungicides			
Difeconazol	0.3	0.4	-0.1
Mancozeb	32	31.2	0.8

Tridemorph	3.4	3.4	0
Pirymethanil	1.8	1.4	0.4
Bitertanol	0.3	0	0.3
Epoxiconazole	0.33	0.5	-0.17
Fenpoprimorf	1.8	2.5	-0.7
Total pesticides	46.8	39.4	7.35

The majority of the active ingredient used on banana is to control Black Sigatoka. Therefore, a strategy based on the application of a series of practices aimed at the reduction of the source of infection was implemented; namely pruning, leaf surgery and weekly defoliation. **La Josefa 4's** programme of sporadic aerial applications, where fumigation is carried out based on the level of incidence of the disease is monitored periodically. Consequently, the use of fungicides is reduced (Table 5).



Farm with "rat leaf" soil covering and without the use of herbicides.

Table 5. Reduction in the use of pesticides on the La Josefa farm (kg a.i./ha/year) achieved on the banana demonstration plots with the implementation of GAP, in comparison to the total amount applied on the plots with conventional practice. Herbicides are not used on this farm.

Pesticide	Quantity (kg a.i./ha/year)		Reduction
	Conventional Practice (initial)	Alternative Practice (final)	kg a.i./ha/yr
Difeconazol	0.2	0.3	-0.1
Mancozeb	29.1	21.5	7.6
Tridemorf	2.70	3.1	-0.4
Pirymethanil	0.9	0.5	0.4
Bitertanol	0.4	0.1	0.3
Epoxiconazole	0.4	0.15	0.25
Fenpoprimorf	0.6	2.2	-1.6
Total fungicides	34.2	27.9	6.45

Neither nematicides nor insecticides are applied on both demonstration farms due to the low incidence of these pests on the banana crop, as well as the costs associated with it and the risk that it poses to occupational health and the environment. With the implementation of GAPs within the framework of the project, **La Yudis** farm raised its productivity level and is currently certified in GlobalGAP. 100% of its production is exported to international markets.

b.2 Good agricultural practices for plantain

Like in banana cultivation, the experience consisted in reducing the use of herbicides to control weeds, and the use of fungicides to control the Black Sigatoka. As a preventative measure, plastic covering with Chlorpyrifos (1%) was used to control insects and manual spraying was done with a fungicides solution to treat the crowns. The daily volume of rainfall was also monitored to venture into precision agriculture.

At the infrastructural level, the areas for the storage and handling of pesticides and post-harvest management were adapted. With previous GAP experience on the **Hermanos Mora** farm, a filtration system was built to capture the pesticide residues generated during pesticides mixing or the washing of the application equipment.



Sediment trap in post-harvest area to prevent runoff.

Weed control was done the same way on the two farms since both have very similar environmental conditions and weed growth. A 3.7 kg a.i./ha reduction in herbicides use on the **El Empeño** farm, and a 4.0 kg a.i./ha on the **Hermanos Mora** farm (tables 6 and 7) were achieved. The strategy included mechanical control with a whipper-snipper complemented by chemical control (herbicides); the management of weeds and the selection of some that were already growing; proper environmental disposal of harvest residues as physical weed control and manual eradication of the more aggressive ones.

Table 6. Reduction in the use of pesticides on El Empeño farm (kg a.i./ha/year) achieved on the banana demonstration plots with the implementation of GAP, compared to the total amount applied on the plots with conventional management.

Pesticide	Quantity (kg a.i./ha/yr)		Reduction
	Conventional Practice (initial)	Alternative Practice (final)	kg a.i./ha/yr
Herbicides			
Paraquat	0.9	0,6	0.3

Diquat	0.3	0	0.3
Glyphosate	4.6	1.5	3.1
Foliar Fungicides			
Mancozeb	6	5.16	0.84
Propiconazol	0	0.4	-0.4
Tridemorf	0	0.7	-0.7
Chlorothalonil	2.88	0	2.88
Total pesticides	14.68	8.36	6.32

For the efficient control of the Black Sigatoka, terrestrial applications with motorized nebulizers are used. Complementary to chemical control, work aimed at the reduction of the inoculums was carried out, among which the following stand out: pruning, defoliation, maintenance of the drainage network, timely control of weeds and the development of a fertilization plan based on the needs of the soil. This strategy kept the plantation robust and with low levels of infection. The use of fungicides went down by 2.62 kg a.i./ha/year on the El Empeño farm and by 1.1 kg a.i./ha/year on the Hermanos Mora farm (Tables 6 and 7).

Table 7. Reduction in the use of pesticides on the Hermanos Mora farm (kg a.i./ha/year) achieved on the plantain demonstration plots with the implementation of GAP, in comparison to the total amount applied on the plots with conventional management.

Pesticide	Quantity (kg a.i./ha/yr)		Reduction
	Conventional Practice (initial)	Alternative Practice (final)	kg a.i./ha/yr
Herbicides			
Glyphosate	5.2	0.9	4.3
Glufosinate Ammonium	0.0	0.3	-0.3
Foliar Fungicides			
Mancozeb	8.4	7.9	0.5
Propiconazol	0	0.2	-0.2
Chlorothalonil	0.4	0.0	0.4
Benomyl	0.4	0	0.4
Total pesticides	14.4	9.3	5.1

On the four farms, an increase in the application of some pesticides was observed as a result of the adverse climatic conditions that occurred from time to time (especially rainy winter) and that had to be done in a radical manner in order to not lose the harvest.

b3. Production costs associated with the new practices

During the assessment of incremental costs of production related to phytosanitary control (inputs and additional staff), very positive results were observed on three of the four farms (Table 8). Production costs and productivity increased with the implementation of good practices and improvements at the infrastructural level. Assuming an approximate value of USD 7 per box produced, an increase in net income for La Josefa 4, La Yudis and El Empeño was achieved. The Hermanos Mora farm did not experience an increase in productivity but production costs per unit were increased, causing a reduction in profits.

Table 8. Comparison of incremental production costs (phytosanitary control) during the implementation of GAP on banana farms (Magdalena): La Josefa 4 and La Yudis, and on plantain farms (Urabá): El Empeño and Hermanos Mora, and their production levels at the beginning and end of the project in US\$/ha/year

Participating Farms	Costs and productivity without GAP in 2008 US\$/ha/year*	Costs and productivity with GAP in 2010 US\$/ha/year**
La Josefa 4 farm	244,0 (832 boxes/ha/year)	373,6 (1.123 boxes/ha/year)
La Yudis farm	85,4 (642 boxes/ha/year)	349,6 (2.424 boxes/ha/year)
El Empeño farm	206,8 (796 boxes/ha/year)	555,1 (887 boxes/ha/year)
Hermanos Mora farm	195,7 (690 boxes/ha/year)	554,5 (690 boxes/ha/year)

*reference rate for 2008, \$1967.11

** reference rate for 2010, \$1,876

c. Environmental benefits

When using the increased water level monitoring methodology on **La Josefa 4** farm, no herbicide residues were detected. These had not been used on the farm since 2004. The presence of fungicides such as Imazalil, used for the treatment of fungi on banana crowns during the maturing stage, was detected. Also detected were Epoxiconazol, Difenoconazol and Pirimethanil, which are applied to control Black Sigatoka. The concentrations of the pesticides found were relatively low, below 1 $\mu\text{g/l}$, and their presence was not consistent throughout the sampling cycle.



Collection of surface water runoff to be later tested for pesticides residue.

La Yudis farm was successful in eliminating the application of the herbicide Glyphosate and its presence was only detected in the drainage canals at the beginning of the validation of the new practices. Glufosinate Ammonium is still used to combat the accelerated growth of weeds, but only during adverse climatic events, and its presence was not detected in the water samples. Among the compounds found in quantifiable concentrations is the fungicide Epoxiconazol, used to control Black Sigatoka, and the herbicides Diquat and Paraquat in relatively high concentrations.

The herbicide Glyphosate was detected in considerably high concentrations ($\approx 140 \mu\text{g/l}$) on **El Empeño** farm during the first sampling, but was not detected in subsequent samplings. In the case of the fungicides Epoxiconazol and Propiconazol, the concentrations found were less than 1.5 $\mu\text{g/l}$ but were consistent. The presence of the Glyphosate (AMPA) and Mancozeb (ETU) metabolites was also detected during the first and last samplings respectively.



Measurement of some water quality parameters in the field.

The concentration of herbicides and fungicides in the canals on **Hermanos Mora** farm was also reduced as a result of the reduction in the application levels of these products. Epoxiconazol and Propiconazol were detected in quantifiable values in the canals, but below 0.5 $\mu\text{g/l}$. A metabolite of Glyphosate (AMPA) was rarely detected, at a concentration of 13.7 $\mu\text{g/l}$, and ETU (metabolite of Mancozeb) was also detected at trace levels.

Glyphosate was detected in concentrations higher than the $\mu\text{g/l}$ during the first sampling on the four farms; it was not detected on subsequent sampling events. In

general, a clear tendency towards the reduction of pesticide residues in the drainage of the farms was noticed. The filtration system installed on the four farms to capture the pesticide residues released during the preparation process of applications or the washing of equipment substantially reduced the pollutant load in the drainage canals, thereby improving the quality of the water discharged.

d. Sharing of experiences

The demonstration project and related training activities were important for the producers to learn innovative environmentally-friendly production techniques without it affecting their profits. The implementation of integrated crop management by means of good agricultural practices minimizes possible risks for the health of farmers, his employees and their families, as well as for the environment, from continuous and prolonged exposure to biocides. A significant reduction in exposure to possible threats was confirmed after the implementation of the GAP. The outputs of the training and technical assistance strategy are summarized in Table 9.



Training activity on a small banana farm.

Table 9. Dissemination of results and lessons learnt as part of the Augura GAP demo project.

Implementing Agency	Training and Technical Assistance	Published Material
<ul style="list-style-type: none"> • Augura banana (small producers) 	<ul style="list-style-type: none"> • 392 workers trained in GAP • 2,684 persons participated in training events 	<ul style="list-style-type: none"> • GAP Manual for Banana
<ul style="list-style-type: none"> • Augura plantain (small producers) 	<ul style="list-style-type: none"> • 394 workers trained in GAP • 740 persons participated in training events 	<ul style="list-style-type: none"> • GAP Manual for Plantain
<ul style="list-style-type: none"> • Augura banana and plantain (small producers) 	<ul style="list-style-type: none"> • The GAP training sessions were complemented by a follow-up to the adoption of GAP in 303 associated farms 	<ul style="list-style-type: none"> • Integrated Pest Management Manual • Safe Handling of Pesticides Manual • Booklet on the Calibration of Spraying Equipment • A video promoting GAP • A crop planner • Weeds Identification poster • Work Risks Prevention poster

		<ul style="list-style-type: none">• An Emergency Plan poster
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3.4 Good Agricultural Practices for the cultivation of pineapple in Costa Rica

Pineapple is Costa Rica's second most important agricultural product for export (SEPSA 2011). According to a report of the National Chamber of Producers and Exporters of Pineapple (CANAPEP 2011), the area used for the cultivation of this fruit is close to 45,000 hectares, of which 50% is concentrated in the North Zone with 98% of the producers, followed by the Atlantic Zone with 1.5% of the farmers on 33% of the cultivated land. It is estimated that the area of influence on the Caribbean coast is about 83% of the total pineapple cultivated in the country.



Pineapple crop in Costa Rica.

CANAPEP (2011) also reports approximately 1,300 pineapple producers in the entire country, of which 1,240 are considered small- and medium-size producers. The pineapple industry generates more than 27,500 direct and 100,000 indirect jobs, making it the total or partial livelihood of more than 550,000 persons at the national level.

The pests and diseases in the pineapple crop are common for all the producers, but the level of incidence and management practices that are carried out will vary according to the production system and the available resources and technology. Periodic technical assistance to the small- and medium-size producers is fundamental, since they are many and can significantly impact on the marine and coastal resources.

3.4.1 Association of small- and medium-size pineapple producers (PROAGROIN Foundation)

Considering the above, the PROAGROIN Foundation carried out an assessment and promotion of alternative management practices for the main pests and diseases of this crop and small producers in the Huetar Region North of Costa Rica were targeted. Based on the increase in phytosanitary problems in the area of influence, the pineapple mealy bug (*Dysmicoccus brevipes*), ants (various species), bacterial rot (*Erwinia sp*) and the fungal rot (*Phytophthora sp*), were selected as the pests which cause major damage to the pineapple crop in this area.

An innovative Integrated Pest Management (IPM) system was introduced for the control of these pests with biological control agents and the reduction in the use of pesticides. Additionally, the alternative management of crop residues was validated based on their incorporation into the soil, through physical and microbiological methods (harrowing and micro-organisms), without the use of herbicides as drying agents. The treatment of this material improves the soil conditions and reduces the problem of stable fly.

a. Participating entities

This demonstration project was developed by the PROAGROIN Foundation, a non-profit non-governmental organization, which organizes about 135 producers of pineapples, among other crops. This foundation facilitates the managerial development of small- and medium-size farmers in the northern part of the country, by providing credit, technical assistance, training and trade, within a social, ecological and economically sustainable framework.

The implementation of these alternative management practices was executed on 2 pineapple farms, the first is in the canton of Upala, district of Colonia Puntarenas with a total area of 17.5 hectares and the second, with an area of 10.5 hectares in the canton of San Carlos, district of Aguas Zarcas. The validations were developed on plots between 0.25 and 0.5 hectares.

b. Validated technologies

b.1 Integrated management of Mealy bug (*Dysmicoccus brevipes*)

For the control of this pest, several known practices that were previously validated were implemented, but these had not been comprehensively applied. These practices include the selection of land considering its health, the selection and the treatment of seedlings, and the weekly monitoring of ants, since these are the principal means of transport for the mealy bug. Similarly, a weed management programme was established in the pathways, since these are the principal hosts of the ants. Monitoring of the incidence and severity of the mealy bug



Trophobiosis between the mealy bug and the ant. The ant transports the mealy bug and protects it in exchange for the nectar present in its exudates.

was carried out every 22 days. Biological/natural control was used and chemical control (Diazinon) to a lesser extent. The latter was applied only in a third of the regular dosage used for the conventional treatment, along with low impact products such as potassium salts soap or a botanic extract (chili based).

The implementation of the new IPM programme resulted in a reduction of the number of applications from ten to four, and in 54.6% the quantity of insecticides applied in traditional management, lowering from 18.3 to 8.3 kg a.i./ha/harvest-cycle. The quantity of product applied for the management of the ant was also reduced, lowering from 3 kg/ha/harvest-cycle of commercial product (sodium octaborate) to only 0.5 kg/ha, using bamboo structures or pineapple leaves to protect the product from the effects of rain.

b.2 Integrated management of fungal rot (*Phytophthora sp*) and bacterial rot (*Erwinia sp*)

In addition to land evaluation, seedling treatment and the monitoring of the incidence of the disease, deep drains were dug to avoid having excessive moisture on the plantation. The biologic-natural control of the rot was done using alternative products such as copper sulphate or quaternary ammonium, and pesticides were only used for the seedling treatment process.

Based on these techniques, there was a 68.7% reduction in the use of fungicides-bactericides; going from 16.6 to 5.2 kg a.i./ha. In addition, by monitoring the disease, the three conventional applications that were carried out prior to flower induction were reduced to two.



Treatment of planting material to prevent fungal rot.

During the implementation of the integrated management practices for the Mealy Bug and Fungal Rot, no significant differences were noticed in crop yield. However, a significant reduction in the costs associated with phytosanitary control of the plantation was observed. Table 10 summarizes the costs.

Table 10. Costs associated with the implementation of IPM and conventional management for the control of mealy bug and fungal rot in US\$/ha/cycle*

	Alternative IPM Control (US\$/ha/cycle*)	Conventional Control (US\$/ha/cycle*)
Control of Mealy Bug	1,053	1,889
Control of Fungal Rot	324	721

* First harvest

b.3 Alternative management of agricultural residues of pineapple (stubble)



The cultivation of pineapple produces a large quantity of vegetable matter during a production cycle of approximately 27 months (two harvests). At the end of this period, the remaining slow-degrading biomass (stubble) should be eliminated and the soil prepared to begin a new productive cycle. The proposal for alternative management practices consisted of the incorporation of the pineapple stubble, making use of physical (harrowing) and physical-microbiological means (harrowing and micro-organisms). These practices eliminated the use of chemical herbicides such as Paraquat which is used as a drying agent of stubble, and the traditional burning of the dried stubble.

Stubble: vegetable material that remains after harvesting a fruit and is incorporated in the soil to improve fertility.

Eliminating the use of Paraquat reduced the total quantity of pesticides applied by 1.7 kg a.i./ha during the pineapple crop cycle. Bear in mind that in tropical zones, 1 kg of agricultural waste, dry and burnt, produces nearly 1.5 kg of CO₂ (Andreae and Merlet, 2001), the generalized application of this practice (physical burning) on all pineapple plantations in the country would release significant amounts of CO₂ in the atmosphere.

The results obtained show that the differential management of stubble by physical methods, and without the use of herbicides, implies a reduction in the costs of production (Table 11). An economic benefit that could not be quantified in the short term is the effect of the improvement of the nutritional characteristics of the soil, namely the increase in pH, magnesium, nitrogen and organic matter, as well as the reduction in excessive levels of iron and manganese after the incorporation process, as these generate benefits in the long term.

Table 11. Production costs associated with the alternative management of stubble in US\$/ha/production cycle

	Alternative management (US\$/ha/cycle)		Conventional management (US\$/ha/cycle)
	Physical-microbiological	Physical	
Cost	638	330	390

* First harvest

c. Environmental benefits

In the areas where integrated management practices were applied for the control of the mealy bug, it was corroborated that there was a very significant reduction in the levels of the insecticide Diazinon, which is normally detected in the soil (monitoring carried out by the Centre for Research of Environmental Pollution, CICA). This molecule appeared only in soils at the end of the cycle, a result of the extraordinary applications which ought to have been carried out before the harvest to fulfill the phytosanitary requirements of the product for its export. The presence of Diazinon was not detected in run-off water.

Herbicides such as Diuron and Ametryne, and fungicides-bactericides such as Metalaxyl and Triadimefon were also found in soils. Residues of Metalaxyl were found in run-off water samples. In the areas where the integrated management of fungal rot was assessed, only Triadimefon was detected in water samples, due to its application during the treatment of seedlings prior to planting; Diazinon was also detected. The presence of Diuron, which is used for the control of weeds during planting, was observed in soils. Generally, the detections were below 100 µg/kg in soils and below 10 µg/l in water, with the exception of Metalaxyl which was found in considerably high concentrations during one of the samplings.

d. Sharing experiences

The experiences gained during the validation of the integrated pest management (IPM) practices were shared with the small pineapple producers in the area of influence of the project through workshops, seminars and publications (Table 12).

The implementation of IPM and alternative management of stubble had a very positive impact on the health of workers. The reduction in the levels of exposure to pesticides (frequency and application dose), mainly to organophosphates such as Diazinon, directly affects the workers. Consequently, the risk of exposure and intoxication to agrochemicals is reduced due to the elimination or substitution of more toxic molecules by others that have less impact on alternative management.

Table 12. Dissemination of results and lessons learnt during the implementation of the IPM for pineapple on small farms.

Implementing Agency	Training and Technical Assistance	Published Material
PROAGROIN pineapples (small producers)	<ul style="list-style-type: none">• 828 participations: technicians (21%), small- and medium-size producers (65%) and others (14%)• Direct technical assistance to about 200 small producers	<ul style="list-style-type: none">• Integrated pest management Manual• 8 technical files on IPM• 6 technical bulletins• 3 publications in the magazine "Pineapples of Costa Rica"

3.4.2 Large producers of pineapple (BANACOL de Costa Rica)

The use of herbicides is the traditional practice employed by producers to keep the crop areas free from the growth of weeds which compete with the pineapple for nutrients, water and light; as well as serve as possible hosts for other types of pests. BANACOL introduced a new IPM programme which includes the use of plastic covering in the crop areas, with the goal of eliminating the growth of weeds and drastically reducing the use of herbicides.



The use of plastic to reduce the use of herbicides and fertilizers.

a. Participating entities

The demonstration project was managed by the Department of Technical Assistance and Agriculture (DATA), of BANACOL de Costa Rica, a firm dedicated to the production and commercialization of agricultural products. The Production Unit has four pineapple farms in Costa Rica, with a total of 2700 hectares. Validation was carried out on the San Cayetano Industrial Agricultural pineapple farm located in the district of Puerto Viejo in Sarapiquí. The size of the demonstration plots was 0.5 hectares on average.

Due to prevailing edaphoclimatic conditions in the area, the San Cayetano Industrial farm exhibited extreme phytosanitary problems, therefore the quantity of agrochemicals active ingredient that was applied was more than the national average.

b. Validated technologies

Plastic covering, a new component of integrated pest management, to control weeds and nematodes, as well as erosion was the main technological innovation employed. The changes to the traditional pineapple production system showed a very positive economic balance (Table 13). Fruit yield after alternative management exceeded 1000 boxes of pineapples per hectare the observed on plots using conventional management. The best sized fruits were harvested from areas with plastic covering.

Table 13. Production costs relative to conventional or alternative management implemented and the estimated productivity on each plot, in US\$/ha/cycle*

Description	Conventional (without plastic) US\$/ha/cycle*	Alternative (with plastic) US\$/ha/cycle*
San Cayetano Farm	4,023.2	4,033.8
Boxes produced	7,129 boxes	8,301 boxes
Cost per box	0.56	0.49

* First harvest

In the sections where plastic covering was used, a 100% elimination of herbicides was achieved in the planting area, and nearly a 32% reduction of those used to control weeds in the surrounding area. The use of nematicides was also reduced by 47%, and 32% of the synthetic fungicide application was substituted by bio-controllers (*Trichoderma sp.*). These reductions were 35% of the total amount of pesticides used in conventional management (Table 14). In addition, the second application cycle of chemical fertilizer equivalent to 214.6 kg of a.i./ha/productive cycle (at first harvest) was eliminated.



Erosion control: the used of plastic, geotextile and the planting of vetiver grass.

Table 14. Reduction in pesticides use on plots with alternative management in comparison to the plots with conventional management in kg a.i./ha/cycle*

PESTICIDE	Quantity (kg a.i./cycle*)		Reduction kg a.i.
	Conventional (without plastic)	Alternative (with plastic)	
Herbicides	25.3	10.2	15.1
Fungicides	23.8	16.2	7.6
Insecticides	18.0	18.3	-0.3
Nematicides	10.9	5.8	5.1
Total	78.0	50.5	27.5

*First harvest.

At the end of the production cycle, the project allowed for the successful evaluation of the extraction method of plastic covering as well as the option of recycling that material. In addition, a new methodology was developed for the disposal of agricultural waste from pineapple (stubble) during the land preparation stage, without the use of herbicides or physical burning. The stubble is crushed and converted into an organic bokashi-type fertilizer (organic fertilizer obtained from fermentation), which is subsequently incorporated into the soil without the presence of stable fly larvae (*Stomoxys calcitrans*).



Collection and crushing of pineapple stubble before the fermentation process to make an organic fertilizer.

For the land preparation stage, production costs to implement GAP were less than those observed for the regular management of stubble, with a US\$135/ha difference in favour of alternative management. The environmental cost for using herbicide as a drying agent for stubble; physical burning was also reduced.

c. Environmental benefits

As part of the validation process, the application of Ametryne, Diuron, Fluazifop-P-butyl and Bromacil was discontinued on plots with plastic covering and, Glyphosate applications on pathways edges was reduced by some 30%.

The presence of residues of Ametryne, Carbofuran, Bromacil, Carbaryl, Diazinon, Endosulfan α and Endosulfa β was detected in soil samples on plots with conventional management (without plastic), in contrast to the plots where plastic covering was used and only the presence of the herbicide Ametryne was observed in the first 60 cm of soil (depth), although it had not been applied.

On the plots where plastic covering was not used, the water run-off had residues of Endosulfan, Diazinon, Triadimefon and Bromacil, in concentrations that practically doubled the maximum limit (5 $\mu\text{g/l}$) established by Canadian environmental authorities for fresh water (Buchman 2008). On plots with alternative management, the presence of Endosulfan, Diazinon, Bromacil and Triadimefon was also detected in water during some of the samplings, but the levels were much lower or almost imperceptible.

For most of the samples, the concentrations detected in soil and run-off water did not exceed the international reference values level, with the exception of Bromacil.

d. Sharing of experiences

The experiences gained during the validation of alternative practices were shared with the pineapple sector by means of workshops, seminars and publications (Table 15).

The changes in BANACOL's productive model has had a positive influence on the health of workers and the population in general since the reduction in the use and application of agrochemicals reduces the risk of an accident or intoxication by exposure to these products. According to the comparative assessment of activities related to pesticides use, no risks that could be regarded as significant or intolerable, or that exposed the health and security of the workers were recorded. The risk observed was of a trivial nature, meaning that no additional actions were required for its control.

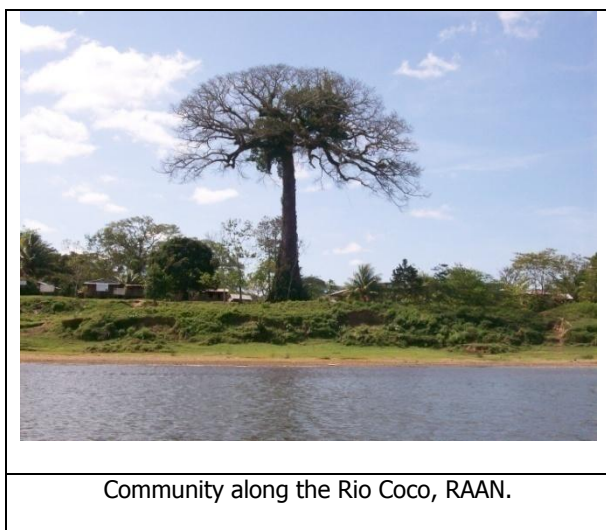
Table15. Dissemination of results and lessons learnt during the implementation of GAP for large-scale pineapple production.

Implementing Agency	Training and Technical Assistance	Published Material
BANACOL pineapple (large producers)	<ul style="list-style-type: none"> • 323 attendees at training events: 61% BANACOL staff, 39% independent producers 	<ul style="list-style-type: none"> • GAP Manual for pineapples • Integrated Management Guide for Pineapple pests • A technical information pamphlet • A video promoting the implementation of GAP

3.5 Good Agricultural Practices for the cultivation of bean and rice in the North Atlantic Autonomous Region (RAAN) of Nicaragua – Bluefields Indian and Caribbean University – Centro Inter Universitario Moravo (BICU-CIUM)

Beans and rice are part of the basic diet of Central American countries. In Nicaragua, the annual average consumption of rice per capita is 51.8 kg (El Nuevo Diario, 2007). For 2009, the national production of rice was 325 thousand metric tons and the area of the land on which the dry cultivation method was used is 22,532 hectares and represented 64% of the total production area in Nicaragua.

In 2009, 394,000 hectares of beans were accounted for at the national level; with a production of 26,989 metric tons and an average yield of 633 kg/ha (MAGFOR 2009). In the Rio Coco communities, RAAN, 60% of the beans harvested is for personal consumption, 30% for sale and 10% is kept for seed. The annual consumption reported in the Waspam area, Coco River, is 40.89 kg per capita. In some communities, the custom is to plant in the river valleys, taking advantage of the sediment that remains after the winter rains.



The cultivation of basic grains in Nicaragua guarantees the population's food security and is part of the culture of the indigenous groups and ethnic communities of the Rio Coco fluvial basin. The part of the production destined for sale contributes to securing economic resources needed for the acquisition of other inputs. The partial or total loss of harvest directly affects the subsistence of the families of the producers.

Owing to the proliferation of pests in the Rio Coco basin over the last few years, pesticides use has increased in this region, reaching 1.52 kg a.i./ha/cycle in beans (90 days average) and 2.25 kg a.i./ha/cycle in rice (110 days on average). The geographic location of these communities facilitates erosion and the run-off of pesticide residues to Rio Coco and finally to the Caribbean Sea. Also, as a traditional practice, the producers apply slash and burn agriculture.

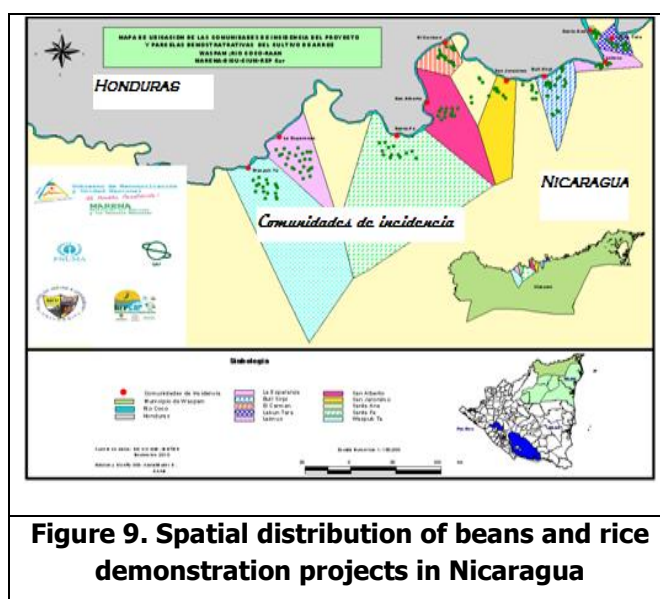
The farmers of the communities of Rio Coco have good ancestral knowledge of crop management practices, but at the same time lack basic techniques and modern knowledge of GAP. This, in addition to the absence of training

programmes, makes them vulnerable to the risks related to the management of phytosanitary products.

The problem of improper pesticides use and their run-off is compounded by the roving and illicit sales of agrochemicals, which are not always prescribed for the crops on which they are used. Out of ignorance, the farmers store these products in their homes and do not adopt the necessary security measures for their management and application.

a. Participating entities

The Bluefields Indian and Caribbean University – Centro Inter Universitario Moravo (BICU-CIUM), coordinated the validation and demonstration of good practices for beans and rice production, in conjunction with 10 indigenous communities along the Rio Coco, located to the west of the town of Waspam: Laguntara, Santa Ana, Leimus, Bull Sirpi, San Jeronimo, El Carmen, San Alberto, Santa Fe, La Esperanza and Waspuk Ta (Figure 9). This university facilitates access to higher education for the different ethnic communities of the RAAN.



The 210 producers who participated in the project live in communities with territorial planning that takes into consideration housing areas, production areas, forest areas and reserve areas. Within the production area, each head of family is assigned a small parcel of land (1.5 ha on average) for the cultivation of his/her crops. The total area of demonstration plots was 105 hectares of beans and 65 hectares of rice. These communities are in an area where economic resources, services and communications are limited.

b. Validated technologies

For both crops, an Integrated Pest Management (IPM) plan was implemented, with emphasis placed on the monitoring and use of physical and biological

tools. Other good practices were equally applied, with the selection of land based on soil quality, cleanness of the area and the use of certified seed.

b.1 Cultivation of beans

To control weeds and improve on the use of space, multi-cropping of beans and corn in rows with handspikes was validated. In this system, the sowing is carried out with a line of corn to every two lines of beans to a depth of 2 to 3 centimetres, with the help of a handspike (cylindrical stick). The corn acts as a barrier in order to reduce the propagation of pests. In the traditional line sowing, the same procedure as before is followed, but without the planting of the corn. In traditional broadcast seeding and without covering the seeds, the costs per land unit are lower, but the yield is very inferior (Table 16). Before all sowing is done, a thin layer of vegetative covering is applied to the soil.



Planting beans in rows with handspike.

Table 16. Production costs associated with the different planting methods for the control of weeds in beans cultivation of, in US\$/ha/cycle.

Planting methods	Costs of production US\$/ha/cycle	Production of beans in kg/ha	Cost US\$/kg
Broadcast seeding	152.6	400.0	0.38
Traditional sowing with handspike	177.6	533.0	0.33
Traditional with handspike in lines	202.6	1,366.6	0.15
Polyculture broadcast seeding	162.6	522.0	0.31
Polyculture with handspike in lines	202.6	855.0	0.24

*Three-month cycle

Multi-crop broadcast seeding (beans and corn) or planting in rows is a strategy for setting up barriers between the crops and thus confuse insect populations. Due to low density corn sowing (100% for personal consumption), productivity was low and was not included in Table 17, but production costs include both crops.



Mixed farming of beans and corn.

The control of insects was based on weekly monitoring with yellow traps for Diptera and traps with stubble and salt water for slugs.

The use of chemical insecticides was substituted by a homemade insecticide made from chilli pepper and liquid soap or a garlic-based insecticide. In some cases, an extract of ground tobacco in foliar sprays was also used. Production increased with the application of the new practices (Table 17) and the production cost of produce per kilogram harvested was reduced.

Table 17. Production costs associated with conventional management practices and new practices validated for the cultivation of beans, in US\$/ha/cycle*.

Crop Management	Cost of production US\$/ha/cycle	Production of beans in kg/ha	Cost of production US\$/kg
Conventional management	307.0	408.6	0.75
Management of insects			
Colour traps	168.5	800.0	0.21
Chilli pepper and liquid soap	250.7	711.0	0.35
Garlic + liquid soap	436.9	600.0	0.73

*Three-month cycle

With the cultivation system implemented, the producers of beans drastically reduced the use of chemical pesticides: the use of herbicides was reduced by 98% and the use of insecticides by 96% (Table 18).

Table 18. Reduction in the use of pesticides on beans (kg a.i./ha/cycle*) achieved on demonstration plots with GAP, in comparison to plots with conventional management practices.

Pesticide	Quantity of a.i. kg/ha/cycle*		
	Conventional (without GAP)	Alternative (with GAP)	Reduction
Herbicides	1.07	0.02	1.05

Insecticides	0.45	0.02	0.43
Total	1.52	0.04	1.48

*Three-month cycle

b.2 Cultivation of rice

The communities of Rio Coco cultivate rice using the dry method (without irrigation). For the control of weeds, the project validated the covering of the soil in the pathways with broad leaves (banana – *Heliconia bihai*, and guarumo – *Cecropia peltata*) to inhibit the proliferation of weeds. The project also evaluated manual control of weeds using machete and hoe in order for them to take a longer time to emerge

As in beans, the control of insects was carried out based on weekly monitoring. Chemical insecticides were substituted by a mix of chilli cabro (*Capsicum sp.*) and soap, and an insecticide made from garlic (*Allium sativum*) and from ground tobacco. With these measures in place, the use of herbicides was reduced by 90% and the use of insecticides by 96% (Table 19).



Farmer setting a trap to capture insects in the rice crop.

Table 19. Reduction in the use of pesticides on rice (kg a.i./ha/cycle*) achieved on demonstration plots with GAP in relation to plots with conventional management practices

Pesticide	Quantity of a.i. kg/ha/cycle*		
	Conventional (without GAP)	Alternative (with GAP)	Reduction
Herbicides	1.8	0.18	1.62
Insecticides	0.45	0.02	0.43
Total	2.25	0.20	2.05

*Four-month cycle

The use of pesticides per hectare on these crops is low, when compared to what is applied on fruits, vegetables or citrus plants; but it is possible to achieve a significant reduction on large areas.

The introduction of new practices for the control of insects and weeds has a high economic cost, mainly due to the hiring of additional personnel to do the field work (Table 20).

Table 20. Production costs associated with conventional management and the different approved practices in the cultivation of rice, in US\$/ha/cycle*

Crop Management	Total production costs US\$/ha/cycle	Production of rice in kg/ha	Cost /kg
Conventional management	552.5	1,997.6	0.28
Management of insects			
Colour traps	404.1	1,409.5	0.29
Chilli pepper and liquid soap	472.0	1,715.0	0.28
Garlic + liquid soap application	625.8	1,335.0	0.47
Management of weeds			
Stubble in pathways	713.4	1,236.0	0.58
Weed control by hoe	722.2	1,227.0	0.59
Weed control by machete	707.4	1,136.5	0.62

*Four-month cycle

c. Environmental benefits

Pesticides run-off from cultivated areas was measured on the plots of two producers. The molecules detected in rice were Methyl Parathion, Dieldrin, Gamma-chlordane, pp-DDT, Heptachlor, Oxamyl and gamma-HCH (Lindano). Beta HCH, Endosulfan, Methiocarb and Sulfone Ardicarb were detected in beans. The majority of the products found have been banned in Nicaragua for some decades now, but due to their persistent nature it is still possible to detect them.

The concentrations detected were relatively low and, according to the reference values reported by Buchman (2008), and are not a threat to aquatic life. A direct relation could not be established between the validated practices and the presence of synthetic pesticide residues in the environment. Considering the high reduction in pesticides use (almost elimination), it could be inferred that the residues would also reduce significantly in the medium-term.

d. Sharing of experiences

The GEF-REPCar Project succeeded in greatly impacting the communities, particularly the more vulnerable groups such as children, women and senior citizens who perform day-to-day agricultural tasks. Producers and their families were sensitized on environmental and health problems that could result from the improper use of pesticides, and the inherent risk of not following the instructions on labels.



GAP training activity for farmers from the RAAN.

216 producers of beans and rice were trained by the project (Table 21) in technical options to improve the environmental management of their crops, without reducing crop yield. All the producers were personally assisted on their plots by technicians of the project and the results obtained were afterwards shared with other communities.

Table 21. Dissemination of results and lessons learnt during the implementation of GAP and IPM for small beans and rice producers.

Implementing Agency	Training and Technical assistance	Material published
<ul style="list-style-type: none"> BICU-CIUM beans and rice (small producers) 	<ul style="list-style-type: none"> 216 producers associated with the project (36% women) trained in beans and rice GAP Training provided for 37 producers in other communities. Training of 34 technicians and owners of pesticides distribution centres on Safe Handling of Pesticides 	<ul style="list-style-type: none"> GAP Beans Manual GAP Rice Manual GAP brochure and pamphlet on the Management of Pesticides poster, promotional calendar, crop planner <p>All the material was translated into Miskito.</p>

3.6 Good Agricultural Practices for the cultivation of oil palm in the South Atlantic Autonomous Region (RAAS) of Nicaragua – Bluefields Indian and Caribbean University (BICU)



Aerial view of oil palm crop in Kukra Hill, RAAS.

The cultivation of oil palm began in Nicaragua in the 1950s with the planting of 500 hectares. Currently, it is estimated that an area of 12,766 hectares is cultivated, the greater part of which (8,311 ha) is planted in the municipality of Kukra Hill (RAAS), located 30 km to the north of the Bluefields Municipality and 415 km to the east of Managua. It is a much undulated coastal area with strong relief. In the surrounding municipality there are

large rivers and innumerable streams between the Rio Escondido and the Rio Kurinwas basins.

Of the total area planted, 7,045 ha are controlled by the Cukra Development Corporation (CDC) and 68 associated producers plant some 1,266 hectares in total. An average of 7 persons is employed on associated farms; this is equivalent to 476 persons directly linked to the oil palm production system in small companies. The project was focused on carrying out alternative crop management practice on these small enterprises. In 2000, Nicaragua exported 77.6 metric tons of palm oil. In 2004, 1,588 metric tons were exported, generating approximately a million dollars. Current exportation data are not available.

Apart from the use of the oil as an ingredient in different industrial processes, the national importance of this product lies in its potential as a bio-fuel. In 2006, the presidency issued a decree and declared the production of biodiesel from oil palm, soya, fig trees, Euphorbiaceae shrubs and other crops, as well as the setting up of extraction factories and oil refineries of “national strategic interest”.

The social and environmental problem associated with this crop is serious, and is a result of the way in which the crop is established. The large-scale palm oil production has severe repercussions on the tropical forests, their inhabitants and their biodiversity, mainly due to the conversion of forests to plantations and the agro-environmental management of same. For the production of oil palm in Kukra Hill pesticides are the main tool for pest control. Traditionally, the small farmers applied pesticides without personal protective gear and did not have a proper management plan for residues and spills. The application equipment

was washed in small streams which are a part of Rio Escondido basin, which flows into the Caribbean Sea. 83% of the farmers (57) do not have a place to store agrochemicals; these are kept at their homes. Approximately 68% of the farmers have not received training in the use, management and storage of agrochemicals, thus increasing the risks of intoxication, spills, run-offs and pollution of the environment.

a. Participating entities

The Bluefields Indian and Caribbean University – Instituto de Biodiversidad y Estudios Ambientales coordinated the demonstration project in the communities of La Fonseca, Big Lagoon, Samuel Law and el Panchón from the Kukra Hill Municipality. An alliance was formed with the CDC which processes the oil palms supplied by the small farmers and facilitates credit for the purchase of supplies and tools. Similarly, CDC provides technical assistance to ensure production and product quality.

b. Validated technologies

New technological alternatives were developed and validated on demonstration plots in each community and focused on integrated pest management, where techniques for the control of weeds and the palm weevil were developed.

b.1 Management of weeds

For the control of weeds on new plantations (0-4 years of establishment), three techniques were validated: covering with a leguminous crop (red beans), mechanical control of weeds using a manual weeder and the covering of the perimeter of the plant with black polyethylene. The use of plastic covering and the planting of legumes (red beans) as alternative treatments for the control of weeds on oil palm plantations, showed very positive results. As a result of these techniques, the use of herbicides was reduced by 22.6%. The quarterly mechanical control was not too effective since, apart from increasing labour costs, its efficiency was low given the early re-sprouting of weeds in the treated area (Table 22).

Covering with red beans crop is used to reduce the population density of weeds and generate more income for the farmers. In this way, the crop is allowed to complete its cycle, up to harvest. Sowing is carried out in the month of December and harvest takes place during the first fifteen days of April (based on the variety of beans planted).

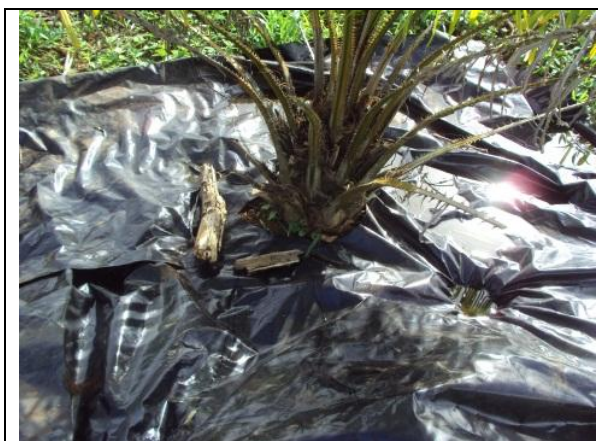


Common bean crop to control weeds in the oil palm plantation in order to reduce the use of herbicides and increase food security of the area.

Besides these benefits, the legumes fix nitrogen, and nutrients are mixed into the soil as the harvest residue is incorporated.

This also contributes to reducing water and wind erosion as a result of its spreading nature. The sowing of legumes is done between rows of palm plants (in the pathways) of an average age of 1 to 4 years. After four years, the palms start to cover the pathways and less weed control is required.

The use of plastic covering on the soil surface around the trunk of the plant reduces the competition of weeds for nutrients and water in this area. The plastic used is black agricultural polyethylene which has a life span of approximately 5 years. Pieces of plastic, 2 metres wide by 2 metres long, are placed on the soil around the trunk of the palm plants and secured with wooden stakes.



The use of plastic covering to control weeds around the oil palm

As a result of the validations carried out for the management of weeds, a combination of plastic covering on soil surrounding the trunk of the plants and the planting of common beans is recommended. Beans production generates a profit of USD 624.25/ha/cycle, and yields 1,320 kg of beans/ha/cycle. The cost of cultivating beans is USD 546.19/ha and the selling price is USD 0.89 per kilogram. With the implementation of these techniques, control in excess of 90% of the

weed population was achieved, thereby reducing the use of herbicides by 23% and the loss of soil through erosion. The cultivation of beans as a covering for the pathways can be carried out at any time of the year, but a good harvest is not always guaranteed, due to climatic conditions in the area.

Table 22. Production cost of validated practices in relation to the cost of the conventional weed management for small-scale oil palm production

Agricultural Practice Carried Out	Management Cost USD/ha/year	Comparison with Conventional Management USD/ha/year
Weed Management		
Conventional (buckets for stirring + herbicides)	402.86	Equal
Establishment of common bean	546.18	143.3 more than the cost of conventional management but with an income of 1,175 for the value of beans.
Management with Machete	430.48	27.6 more than the cost of conventional management.
Management with Plastic	163.45	239.4 less than the cost of conventional management.

b.2 Management of the Palm Weevil (Rhynchophorus palmarum)

For the control of the Palm Weevil, insect pest of oil palm in Kukra Hill, the use of bait in plastic traps was validated. The traps are hand-made from gallon plastic containers cut out on both sides to a height of 15 centimetres. The bait is placed inside the container, and is protected from the direct sunlight and rain. Made from an attracting agent (aggregation pheromones or, in their absence, pieces of pineapple) and molasses diluted in water, the bait prevents cutaneous respiration of the insects that fall into the container. Pheromones are sexual hormones that attract males and this type of bait attracts the largest number of adult palm weevil. A trap is installed on every three hectares and the pheromone changed every 10 days, this is considered as high-density trapping. Among other bait alternatives, the fermented pineapple is the next best attracting agent. The relationship between costs and the different management options is summarized in Table 23.



Table 23. Relationship of incremental production costs with the validated practices for the control of Palm Weevil in oil palm in USD/ha/year

Crop Management	Incremental costs with GAP US\$/ha/year
Conventional management	47.90

Management of the Palm Weevil	
Fermented sugar cane	23.10
Fermented common banana	27.13
Pineapple + Molasses	23.86
Aggregation Pheromone + molasses	37.57

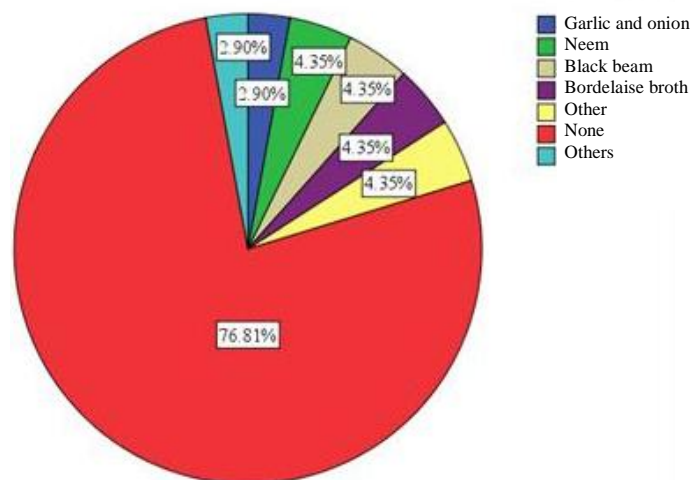
The use of pesticides per hectare on a perennial crop such as the oil palm is relatively low (Table 24), when compared to other crops like banana, vegetables or ornamental plants, but considering the planted area in Kukra Hill, the climate and the geography, there is an obvious risk of pollution of the water bodies and coastal areas.

Table 24. Reduction in the use of pesticides on oil palm (kg a.i./ha/year) achieved on demonstration plots using soil covering and IPM for the control of Weevil, in comparison to plots under conventional management.

Pesticides	Conventional kg a.i./ha/year	Alternative kg a.i./ha/year	Reduction Kg a.i./ha/year
Herbicides	5.22	4.04	1.18
Insecticides	5.16	3.99	1.17
Total	10.38	8.03	2.35

At the end of the project and based on the results obtained, it was calculated that about 25% of the small- and medium-size producers of palm were already implementing an integrated management programme. An example is the use of bio-pesticides on 22.6% of the farms (Figure 10), which is significant if it is considered that no farmer was applying biological techniques at the start of the project.

Figure 10. Types of bio-pesticides used on the farms associated with the oil palm demo project.



The degree of adoption is still low. The producers still think that there is a high risk of increasing the Palm Weevil population by excluding the use of synthetic pesticides. Therefore more time is needed for the dissemination of results and awareness raising to promote the implementation of GAP.

c. Environmental benefits

In the monitoring of the pesticide residues carried out on surface waters on the demonstration plots, only the presence of Aldicarb, Sulfon and Oxamyl was detected in two of the four communities, and in concentrations below the guide values established by the US-EPA and the WHO for drinking water. It was not possible to establish a relationship between the new practices promoted by the project and variations in the results of the monitoring of residues on farms.

Sharing of experiences



Technical assistance being given to small oil palm farmer.

Producers and technicians from 64 farms were trained (Table 25) in GAP and IPM on their plots. In the training sessions they were also taught other pest control techniques, which have been adopted by the producers (see Figure 10 on Bio-pesticides). The personnel of agrochemicals distribution centres were also trained and instructed on the safe handling of pesticides.

Table 25. Dissemination of results and lessons learnt during the implementation of GAP and the IPM for small oil palm producers.

Implementing Agency	Training and Technical Assistance	Published Material
BICU Bluefields (small- and medium-size producers associated with large enterprises)	<ul style="list-style-type: none"> • 195 workers on 64 farms received GAP training • 29 owners of pesticide distribution centres trained in the safe handling of pesticides 	<ul style="list-style-type: none"> • Series of GAP manuals (Integrated management of pests, weed management, organic fertilizers, safe handling of pesticides) • Two posters, a promotional calendar, 2 pamphlets • Technical poster on the insect identification of

4. Learning by doing: Training in good agricultural practices – GAP, integrated pest management - IPM, and best management practices for pesticides – BMPP

As a complement to the training sessions offered by the demonstration projects, the GEF-REPCar project developed GAP, IMP and BMPP training programmes for producers and agricultural technicians. The objective was to train a large number of beneficiaries who were not directly related to the demonstration projects, and sensitize the rural communities about the environmental and health problems that pesticides can cause if they are not appropriately handled. This training and awareness campaign was financed with resources from **CropLife LA**.



4.1 Colombia

Within the framework of the GEF-REPCar Project, the **Sociedad de Agricultores de Colombia (SAC)**, in

coordination with the Ministry of the Environment, Housing and Territorial Development, implemented a training and awareness strategy in GAP and the safe handling of pesticides. This programme targeted approximately 5,000 farmers and agricultural workers in 24 departments of the country, mainly on the Caribbean coast.

To facilitate the training sessions, SAC prepared different didactic materials and publications: pamphlets and posters on the importance of GAP, a field activities planner which facilitates the recording of activities, and a series of posters with practical solutions for reducing the incidence of pests.

4.2 Costa Rica

In Costa Rica, the **Centro Nacional de Alta Tecnología (CeNAT)** developed an awareness and technical training programme which was aimed at producers and technicians of pineapple, banana, plantain and vegetable crops, in the cantons in the centre and to the east of the country. Eight hundred and eighty (880) persons participated in the different types of training events which were adapted to the audience and topic to be presented: seminars, discussion workshops, specialized courses, lessons learnt workshops in the cultivation of pineapple and banana and, technical visits to farms. The activities took place in the regions of North Huetar, Atlantic Huetar and East Central. CeNAT organized specialized courses in the South Central Region for agricultural professionals.



Apart from considering aspects of GAP and BMPP, the producers and technicians were trained in the use of biological inputs, the national and international regulations on the subject of pesticides and the requirements for accreditation of their production processes. In the specialized courses the environmental destination of pesticides was addressed: degradation and the movement of pesticides molecules through the soil and subsoil, and possible management alternatives.

A series of educational materials was prepared to complement the training: pamphlets on GAP in pineapple and banana, and on biological inputs for pineapple production, articles on pesticides run-off and safe handling of agrochemicals.

4.3 Nicaragua

The Instituto de Capacitación e Investigación en Desarrollo Rural



Integral (ICIDRI) de la Universidad Politécnica de Nicaragua (UPOLI) developed a training programme for technicians who specialize in the cultivation of beans, rice, oil palm, cabbage and tomatoes. The workshops and seminars took place in Matagalpa, Jinotega, Bluefields, Puerto Cabezas and Siuna, and 196 technicians and farmers (24% women) were updated on GAP-related topics. These training sessions were also complemented by the promotion of GAP principles in the Caribbean region and North Central Nicaragua.

To facilitate the learning process, UPOLI prepared technical manuals on GAP for different crops as well as on BMP of pesticides, booklets on the biological cycle of the three (3) principal pests of rice, beans and oil palm, and posters on the safe handling of pesticides and the measures to take in case of accidents. Various manuals and methodological tools were compiled in digital format by the programme.

5. Promoting the implementation of innovative practices

With the objective of encouraging the large-scale adoption of new agricultural practices and achieving a significant reduction in pesticides run-off to the coasts, GEF-REPCar supported the revision of the national policies and legal frameworks as well the development of crop certification programmes in Good Agricultural Practices (GAP). The activities developed in each country reflect its national needs and priorities.

5.1 Colombia

Among the actions executed within the framework of the project was the compilation of the legal regulations undertaken by the Cámara Procultivos de la Asociación Nacional de Industriales (ANDI), which is summarised in the "Handbook for the responsible environmental management of chemical pesticides for agricultural use in Colombia". This document was submitted for public consultation in May 2011, before being finalized and published.

As a complement to the legal framework in force, the Ministerio de Ambiente, Vivienda y Desarrollo Territorial issued a resolution with the requirements for obtaining a tax incentive for investments that generate environmental benefits. With this measure, an environmental improvement in the production processes is expected. This resolution applies to all the productive sectors including agriculture.

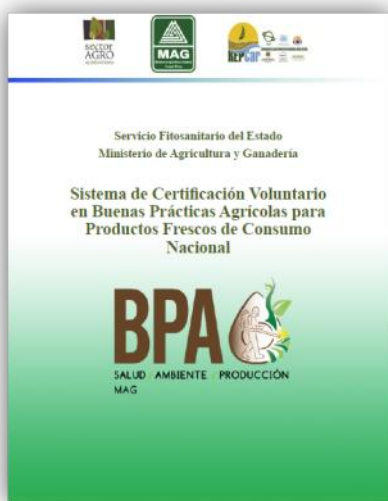
The national GAP regulation "GAP Certification in the primary production of fresh fruits and vegetables" which was developed in 2009 was promoted through the project. The regulation would be implemented under the leadership of the Ministerio de Agricultura but requires promotion. One hundred and fifty-five (155) representatives of large and small



supermarkets in Bogota, Medellin and Barranquilla were made aware of the benefits of marketing agricultural products produced using clean agricultural processes (GAP). The initiative was well received by the local supermarket chains.

5.2 Costa Rica

Costa Rica has a very complete legal framework on the subject of pesticides management, and the national priority is the generation of mechanisms for its enforcement. The project compiled the legal framework related to pesticides and developed a proposal for GAP certification, based on the obligation of the Ministerio de Agricultura y Ganadería (MAG) to follow-up on the safety of agricultural products.

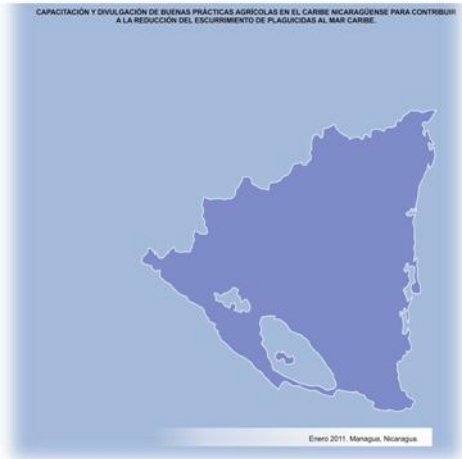


The proposal on “Voluntary GAP certification for fresh produce for national consumption” was developed by the country’s Phytosanitary Service, MAG in coordination with the Ministerio de Ambiente, Energía y Telecomunicaciones (MINAET). The initiative seeks to guarantee the quality of the agricultural products which are consumed in national markets, as well as control the environmental impact of the productive processes from which they are derived. The strategy to follow is the adoption of GAP and BMP by controlling the production processes.

The proposal was discussed with delegates from the public and private sector being represented by different chambers and producers associations, some local marketers, agricultural certification bodies, universities and civil society. The idea was well received among the sectors consulted.

5.3 Nicaragua

Nicaragua compiled the legal framework regarding the management of pesticides which is presently in force. Complementarily, the Universidad Politécnica de Nicaragua (UPOLI) developed a proposal for a norm that will regulate the general pesticides law, Law 274: “Use, management, transport, storage, marketing, aerial and land application of pesticides and the management of empty containers”. The regulation was discussed with the members of the National Coordination Committee (Ministries of Agriculture, Health, Transport, Environment and Natural Resources and Labour, with universities and the private sector), for subsequent endorsement by the Ministry.



A strategy was also developed for the promotion of GAP certification to complement the legal framework. A national event was staged with the participation of Rainforest Alliance, GlobalGAP and MAGFOR, exposing the delegates from the public and private sector to the experiences in the certification of agricultural processes. The initial stage of the certification schemes in Nicaragua was supported by these activities.

6. Conclusions and Recommendations

The GEF-REPCar Project was established based on the need to reduce the accelerated degradation of the coastal and marine ecosystems of the Southwest Caribbean. The high use of pesticides and other agrochemicals, linked to the intensive agricultural production systems being used at present, is one of the sources of pollution that threaten these ecosystems. The Southwest Caribbean is a region with flourishing agricultural activity that consumes a significant amount of pesticides. Its average annual importation (during the 2004-2009 period) was 30.8 thousand metric tons of active ingredient in Colombia, 11.2 thousand metric tons in Costa Rica and 2.7 thousand metric tons in Nicaragua. Pesticides are an important element of the management strategies for agricultural pests, but inappropriate use can result in the runoff of residues to the coasts and directly affect the coastal and marine ecosystems.

6.1 Pesticides found in the coastal environment

Fungicides are the most imported pesticides in Colombia and Costa Rica, with Mancozeb being the most popular fungicide which is used for combating fungi in multiple crops in both countries. In Nicaragua, herbicides are the most imported products and the active ingredient in great demand is the 2,4-D. Despite the sustained use of these products, the monitoring of pesticides residue carried out by GEF-REPCar in about 64 stations during the period 2008-2010 showed relatively low levels of residues in the environment. Only 1.9% of the total number of analyses in water bodies showed quantifiable concentrations. The majority of the pesticide compounds is not very soluble in water so they adhere to soil particles; for this reason a more significant amount of residue was found in sediments with 3.8% of quantifiable values.

In general, the concentrations found during the coastal monitoring exercise were low when compared to international standards. Nevertheless, some molecules are of concern due to their frequent detection, namely Dieldrin, Lindane, Chlorpyrifos, Diuron, Endosulfan and its metabolites, and DDT metabolites. Some of these pesticides are authorized for use, while others have been banned for many decades in the three countries. Lindane and Endosulfan have recently been added to Annex A of the Stockholm Convention, so the countries which still use them are preparing to substitute them.

It is important to highlight the experience and quality of the centres of excellence in environmental studies in the region, and that they participated in the monitoring of pesticides. This was fundamental to the credibility of the results obtained and their appropriation by the agricultural sector. The project succeeded in establishing a database, which can be consulted via the Internet

by officers of the ministries of environment, and arranging meetings and events to review policies and pesticides management strategies. The participation of the private sector in these meetings was very evident, thus demonstrating its commitment to reducing the environmental impact stemming from poor management of pesticides.

It is now necessary to provide continuity to the monitoring initiated and strengthen alliances with other environmental monitoring programmes at the regional and global levels. It would be valuable to expand the programme to other countries, while Colombia, Costa Rica and Nicaragua focus on new sampling locations and follow-up on those compounds and sites that are a cause for great concern. It would be essential to include the frequently used pesticides that could be monitored by GEF-REPCar in this new exercise. For this reason, it is important to continue strengthening the capacities of the environmental research centres in the region.

Besides broadening the monitoring programme, the need to go in depth in the diagnosis of sources of pollution and to work on the search for and implementation of control strategies is evident. Hence, it is therefore important to use a comprehensive approach which takes into consideration the fragility of ecosystems, the regulations for importation of pesticides and the control over the use of banned phytosanitary products. The development of strategies will require major political will, the revision of the control mechanisms and the quest for sources of financing.

6.2 Application of innovative practices in the agricultural sector

With the goal of directly influencing the use of pesticides on some of the most important crops in the region, the GEF-REPCar Project established links with growers' associations and entities specializing in innovation for the agricultural sector. Through a series of demonstration projects, the Project worked on the validation and demonstration of technologies, which were adapted to the needs of the farmers. By doing so, the Project fostered the development of local skills and guaranteed the empowerment of the beneficiaries, which promotes the sustainability of the activities after the closure of GEF-REPCar.

The technical and scientific validation of different innovative agricultural practices, such as the introduction of the systematic monitoring of pests, the use of biological controllers and of soil coverings, established a link between the results of the research conducted at the experimental level and their application at the commercial level. This led to a very significant reduction in the use of synthetic pesticides on the pineapple and banana demonstration crops in Costa Rica, on banana and plantain in Colombia and on beans and oil palm in Nicaragua. Following the introduction of good agricultural practices, reductions

ranged from 8% to more than 50% in some of the demo projects, depending on the sanitary problems of the demo crop and experiences in the introduction of good agricultural practices prior to the Project.

In several cases, the demonstration projects showed a reduction in the presence of pesticides residue in the surrounding water bodies, but due to the complex dynamics of the degradation and mobility of these molecules in the environment it was not possible to establish a general cause-effect relationship. The proposals for technological innovation were, for the most part, translated into an economic benefit for the farmer, reducing production costs per unit. Similarly, the reduction in the frequency and, in some cases the levels of exposure to pesticides, would result in a potential health benefit for farmhands.

Using the advancements achieved by the demonstration projects of GEF-REPCar as foundation, it would be very useful to extend these experiences to other countries in the region and to a greater number of crops. Because of their increasing agricultural activity, it would be important to consider other Central American countries, as well as the larger Caribbean islands.

6.3 Multiplication of benefits generated by the demonstration projects

The GEF-REPCar demonstration projects and complementary training and awareness projects, “Learning by doing”, succeeded in significantly impacting the rural population in the areas of influence. The demonstration projects provided technical assistance to several hundreds of farmers associated with them. In addition, more than 12,000 attendances participated in training and awareness activities regarding good agricultural practices, integrated pest management, best management practices for pesticides and related topics. After these training sessions, many producers have modified their production system by implementing GAP.

It is important to recognize the technological limitations of this type of demonstration projects and agricultural training, since these are not expected to substitute the work carried out by the research centres of the different agricultural associations, national institutes or international organizations on the subject of agricultural development. This task requires continuity in order to build a solid technical base that could be the foundation for demonstration projects and training programmes.

6.4 Complementary actions to strengthen the reduction in the use of pesticides

As a complement to the work of the monitoring programme for pesticides residue, demonstration projects and training and awareness activities, GEF-REPCar encouraged the dissemination of the legal framework in force on the subject of management of pesticides in each country. Similarly, national crop-certification programmes in good agricultural practices were promoted. Colombia had already established a programme, Costa Rica developed a national certification programme and Nicaragua carried out exploratory work. These activities were carried out in association with the productive sector, but greater sensitization of retail organizations and consumers on the benefits of distributing and consuming GAP-certified products is needed.

The promotion of legal frameworks and a more pressing demand for quality products are factors that, in the future, will multiply the impact achieved by the GEF-REPCar Project. The international markets have made significant progress in this area, but the introduction of GAP-certified production on the national markets in the region is still in the early stages of development, which is why it is important to dedicate more efforts and resources to this subject. The massive implementation of Good Agricultural Practices and Best Management practices for pesticides can be driven by markets and public opinion, but this requires the buy-in of all stakeholders of the agricultural system, particularly the farmers and pesticides distributors. These stakeholders should assume their responsibility with regard to the conservation of the environment and the preservation of the health of workers and consumers. A very positive tendency has been observed in the participating countries of GEF-REPCar.

The GEF-REPCar participated in various networks and actively spread its achievements and experiences in more than 50 national and international events of a technical, scientific or policy nature in which it participated. The demonstration projects also prepared numerous technical publications that were complemented by national publications that integrate all project components.

6.5 Final Comments

The results obtained and the successes achieved during the execution of GEF-REPCar are the result of the constant inter-institutional coordination among government entities, the productive sector, universities and UNEP. The participation and contributions of the different stakeholders during the execution of the project contributed to its success.

Through the execution of its different components, the GEF-REPCar Project has succeeded in significantly impacting the reduction of pesticides run-off to the coasts and the potential degradation of the coastal and marine environment. The different activities carried out directly or indirectly influenced specific aspects of national policy regarding the management of pesticides, changes to

legal frameworks, and the strengthening of established institutional capacity. An important baseline on pesticides residue in coastal environments has also been generated, and the information is being utilized for new actions. The most obvious impact is the improved awareness of producers on environmental issues and the change in their method of production in the areas of influence of the project, thanks to the extensive dissemination of the results obtained. For the most part, these successes are due to the strategic alliances established between the public and private sectors, to the of south-south cooperation model built up during the project, to the exchange of experiences, to training sessions held and to the responsible sharing of information.

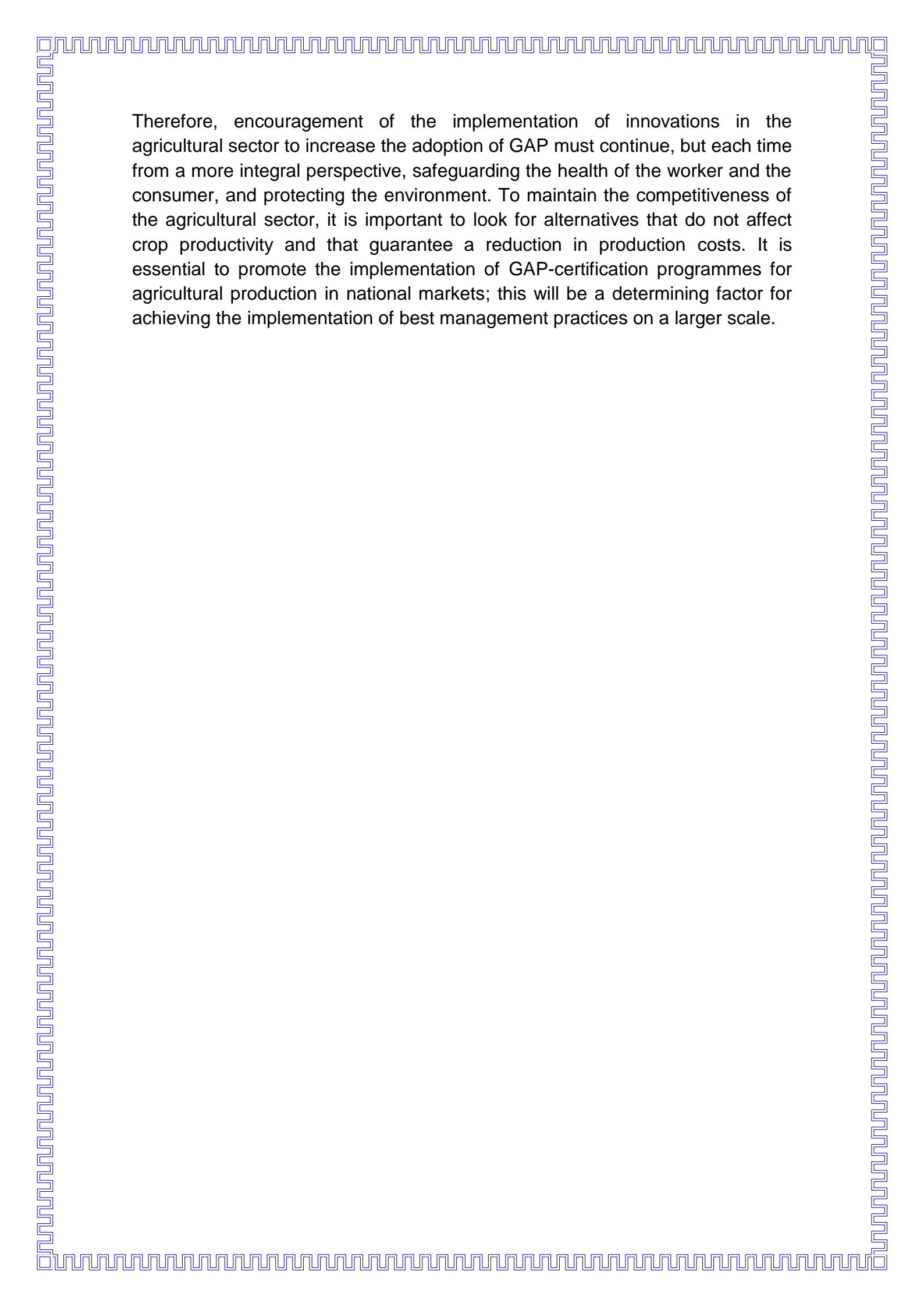
6.6 The way forward ...

Based on the successes and lessons of the GEF-REPCar project, the next goal is to continue sensitizing the relevant persons on the effects of the improper use of pesticides, and to promote changes in the management systems within the agricultural sector of the southwest Caribbean, bearing in mind that the coastal and marine ecosystems are the main resources for the coastal economies. The experiences and recommendations of GEF-REPCar are the basis for the development of new projects that are aimed at the total elimination of Persistent Organic Pollutants and other agrochemicals products that can highly impact the ecosystems.

In a new project, the geographic scale will have to be broadened to include much more countries and a wider variety of crops. It would also be necessary to improve the use of agrochemicals products in the developing tourism sector in coastal areas. For a more integral and life cycle approach, progress must be made regarding the proper management and final disposal of existing obsolete stocks of POPs and pesticides. This requires a greater strengthening of institutional capacities in all the countries of the region.

The monitoring of pesticides residues in the environment initiated by the project is required as a systematic and long-term activity. Follow-up in high-risk areas should be accompanied by the development of ecosystemic management plans that are not limited to the agricultural sector. Other potential sources of pollution and its direct effect on human health should also be considered.

The current proposal or the validity of Free Trade Agreements of some countries of the region makes the need for transforming national legal frameworks into international agricultural regulations quite obvious and gives more validity and urgency to the use of GAP in the region. These actions will directly affect the joint agricultural trade of these countries.



Therefore, encouragement of the implementation of innovations in the agricultural sector to increase the adoption of GAP must continue, but each time from a more integral perspective, safeguarding the health of the worker and the consumer, and protecting the environment. To maintain the competitiveness of the agricultural sector, it is important to look for alternatives that do not affect crop productivity and that guarantee a reduction in production costs. It is essential to promote the implementation of GAP-certification programmes for agricultural production in national markets; this will be a determining factor for achieving the implementation of best management practices on a larger scale.

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