EVALUATING IMPACTS OF COSTA RICA'S ORGANIC FARMING TRAININGS:

A Social, Economic, and Environmental Evaluation of the Mountain Microorganism Training Program in the Eastern Central Region of Costa Rica

Kailey Castellano, Veroniki Nikolaki, Katie Picchione, Kayleigh Sullivan

May 6th, 2015

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For

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ABSTRACT

Since 2012, El Ministerio de Agricultura y Ganadería (MAG) of Costa Rica's Eastern Central Region has trained farmers to grow organic produce using natural soil bacteria known as Mountain Microorganisms (MM). To date, MAG's MM Training Program has not been evaluated. This report explores the efficacy and the social, economic, and environmental impacts of this program. We used interviews, focus groups, farm visits, and training observations to confirm the program's efficacy: it improves farmers' quality of life. Our recommendations highlight opportunities for MAG to enhance and expand the MM Training Program.

ACKNOWLEDGEMENTS

Our team is sincerely grateful to many individuals and groups, from Worcester, San Jose, and Cartago, who provided us with the opportunity to study Mountain Microorganisms and organic agriculture. We would specifically like to thank the following institutions, organizations, and individuals who helped this study come to fruition:

First, thanks go out to El Ministerio de Agricultura y Ganadería, MAG (The Ministry of Agriculture and Livestock) for sponsoring this eye-opening project and accommodating our travels throughout the Eastern Central Region. We thank MSc. Guillermo Flores Marchena for commissioning and coordinating this project. With the help of Ing. Omar Somarribas, we gained new perspectives on organic agriculture.

We are especially grateful to Ing. Rolando Tencio, who dedicated countless hours of his time to coordinate interviews and focus groups with farmers across the Eastern Central Region, take us to farms, and introduce us to new people and ideas. His passion and devotion to this project have inspired us to learn more about organic farming than we knew existed. His continuous engagement, help, time, efforts, and valuable knowledge propelled this project beyond our expectations of the Interactive Qualifying Project (IQP) experience.

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AUTHORSHIP

The writing of an IQP report is a great undertaking. Our team developed a collaborative and iterative writing process to produce this report. Each section was discussed and outlined thoroughly before it was written. Often, all four teammates drafted and crafted each section to create the most accurate portrayal of our work. Sentence by sentence, word by word, we established the content and reviewed our work. Some sections were edited and restructured by two of us at a time in rotating pairs. At the end the entire report was refined in a group review. Our roles in the project are described further in Chapter 3: Methodology.

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GLOSSARY OF AGRICULTURAL TERMS AND ACRONYMS

APASVO – Asociación Producción Agrícola Sostenible Valle de Orosi

Agrochemicals – pesticides, insecticides, fungicides, and fertilizers that are made of synthetic compounds and used to improve the health of crops. The toxicity of agrochemicals is marked by a colored labeled: red is highly toxic, yellow must be used with caution, blue should be used with care, but is less toxic than yellow, and green is the least harmful.

Araña Roja – pest in the Ácaros taxon of arachnids containing mites and ticks. *Tetranychus urticae* included in this taxon, is the red spider in the Eastern Central Region of Costa Rica. It is a prevalent insect pest causing leaf discoloration and death (Bayer Crop Science, 2013)

Apiche – biopesticide originating from a mix of garlic, hot peppers, black pepper, liquid MM, alcohol and water. (Tencio Guide, 2014)

Begomovirus – virus transmitted by mosca blanca that affects crops (Tencio Pamphlet, n.d)

Bioinsumos – products such as organic fertilizers and pesticides that are made from biological agents. When applied to crops, bioinsumos can be less costly and less harmful than conventional products. (Tencio)

Bokashi – Organic composting method that uses a mixture of microorganisms to accelerate decomposition by fermentation and reduce smells (Ketchum, 2013)

Chayote – edible, light green fruit in the gourd family

EM – Effective Microorganisms

EMRO – Effective Microorganisms Research Organization

Eutrophication – the introduction of artificial substances or chemicals into aquatic ecosystems, resulting to the development of algae that compete with the aquatic organisms for space and oxygen (Gliessman, 1998)

Fumigation – Conventional agricultural practice, which involves the release of gaseous pesticides into an area in order to kill crop-eating insects (Australian Government Department of Agriculture, 2015)

Hongos – fungi including yeasts, molds and familiar mushrooms (Lepp, 2013)

Insumos – a chemical or product that is applied to facilitate crop growth. Conventional insumos include chemical pesticides and herbicides, synthetic fertilizers, and additive nutrients. (Tencio)

JICA – Japanese International Cooperation Agency

Late blight – Plague caused by *Tiz*ón that results in lesions and rotting of the leaves, causing death of the leaf and crop (Uchida, n.d)

Lombricompost – compost made when worms decompose organic material. Most commonly, California Red Worms are kept in a dark container and fed with cow manure and other farm waste. Lombricompost is rich in soil nutrients and used in several applications with MM.

M5 – an MM based insecticide, nematicide, and fungicide made with garlic, hot peppers, onion, ginger, molasses, vinegar, alcohol, water, and liquid MM. This mixture is fermented for 15 days and then applied to crops to protect from various pests

MAG – El MInisterio de Agricultura y Ganadería

Monoculture – Conventional agricultural practice of sowing only one crop in a field, allowing for efficient and high-yield cultivation (Gliessman, 1998)

Mosca blanca (*Bemisia Tabaci)* **–** a small homopterous insects of the family *Aleyrodidae* that are injurious plant pests. Whitefly is prevalent in the Eastern Central Region of Costa Rica feeding on the sap of plants covering them with honeydew (Merriam-Webster, 2015)

Mountain Microorganisms (MM) – Beneficial bacteria and fungi sourced from decaying leaves in the forest that are fermented to create solid and liquid biofertilizers and biopesticides. (Tencio Guide, 2014)

Ortiga – biopesticide made from ortiga plant leaves, of the genus Urtica, MM, molasses and water.

Productor – Spanish word for farmer or food producer

Tizón (*Pytophthora infestans)* **–** a fungus that infects tomatoes and potatoes (Uchida, n.d).

Toppling nematode (*Radopholus similis)* **–** pest that causes lesion formation in the roots of plants, leading to malnutrition of the plant (Lotter, n.d)

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EXECUTIVE SUMMARY

BACKGROUND

"Panza llena, corazón contento," is a Spanish phrase meaning "full belly, happy heart." While food is important in all cultures and societies, Costa Ricans, or 'Ticos' use this phrase to convey that food also provides nourishment and gathers people together around the table. In Costa Rica, a developing Central American nation pursuing sustainability, food links society, the economy, and the environment through agriculture. When sustainable, agriculture balances people, prosperity, and the planet, providing opportunities for a better quality of life.

Sustainable agriculture has environmental, economic, and social dimensions. Growing crops depends on the health of the earth; farmers depend on crop yields to achieve economic stability. Equilibrium exists between the social and economic needs of the farmers and the environment. When one part is unbalanced, issues arise for farmers.

Sometimes agricultural balance is disrupted by seasonal and climate changes. Each season brings different plagues and pests that damage plants and threaten crop production and farmers' livelihoods. To mitigate these threats, farmers turn to agrochemicals. However, just as bacteria develop resistance when antibiotics are overused, agricultural pests become resistant to agrochemicals over time. Agrochemicals must then be used more frequently to combat pests and plagues. Over the past 30 years, Costa Rica has become one of the largest importers of agrochemicals in the world (University of Costa Rica, 2010).

Although many farmers depend on agrochemicals, they have myriad unfavorable social, economic, and environmental consequences. Studies have shown that agrochemicals have negative impacts on the environment by affecting crop and soil quality, ultimately leaching from the soil into water and food sources (Gliessman, 1998). When chemicals percolate into food and water supplies, they threaten the health of the people. In Costa Rica's Eastern Central Region, gastric cancer is prominent and has been tied to agrochemical use (Veerman, 2001).

Additionally, agrochemicals are expensive for farmers, who can spend upwards of $5,000 (₡3,000,000) on crop production per year (Tencio, 2014).

Recent years have seen a global paradigm shift away from agrochemicals toward more sustainable techniques. The Ministry of Agriculture and Livestock (MAG) in the Eastern Central Region of Costa Rica has recently begun to teach agricultural sustainability through organic farming techniques. In 2012, Ing. Rolando Tencio, an agronomist at MAG, started an initiative to teach Mountain Microorganisms (MM), a sustainable organic technique, to farmers across the Eastern Central Region.

MM is a technique that uses naturally occurring species of bacteria and fungi from surrounding forests to make natural pesticides and fertilizers. Farmers collect decaying matter and mix it with water, molasses, and rice shells. This mixture is placed in an airtight container and left to ferment for fifteen days. Farmers use this mixture, called solid MM, to make various types of organic pesticides and fertilizers (Tencio, 2015). MM's versatility and accessibility enable farmers to take economic stability into their own hands, while making a difference in environmental and public health.

Currently, MAG teaches this technique in a three-step training program run by Ing. Rolando Tencio. The training includes sessions of theory, practice, and assessment (Figure 1). During the first session with farmers, Ing. Tencio introduces the theory behind MM through a PowerPoint presentation and a series of booklets and handouts. In the second session, he offers a practicum wherein farmers are taught to make various MM products through demonstration and active participation. This session provides an opportunity for farmers to complete hands-on learning through cooperation between the trainer and the trainees. In the third session, Ing. Tencio travels to each farm and assesses the implementation of the techniques by looking at the quality of the farmers' MM products and the quality of their crops. From this assessment, he provides suggestions and recommendations on how to improve their use of MM for better results. He follows up with the farmers until they can implement the techniques correctly.

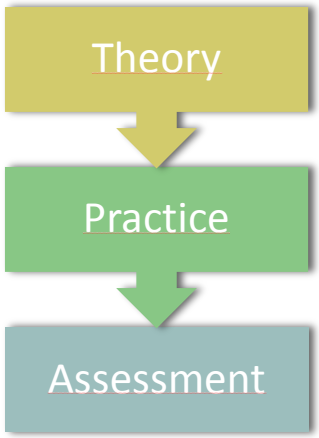

Figure 1. The current model of MM trainings

Since the first training in 2012, Ing. Tencio has expanded the MM Program to reach over 200 farmers in the Eastern Central Region. The program started small in December of 2012, with theoretical sessions of only 14 people, but it has since evolved to the three-step training process. Within the last year alone, Ing. Tencio individually trained over 100 farmers. Between

January and April of 2015, he trained 66 farmers and plans to train more. The MM Program is expanding by word-of-mouth from the many farmers who learn MM techniques in the trainings; however, the techniques, trainings, and impacts of the program have yet to be evaluated.

METHODS

The purpose of this study was to evaluate the MM Program as a whole. In order to achieve this goal, we completed the following objectives:

OBJECTIVE 1: Become knowledgeable about agricultural techniques and trainings in Costa Rica
OBJECTIVE 2: Evaluate the efficacy of Mountain Microorganism techniques
OBJECTIVE 3: Evaluate the efficacy of the Mountain Microorganism trainings
OBJECTIVE 4: Evaluate the social, economic and environmental impacts of the MM Program

To complete these objectives, we utilized economic data reports from MAG and used individual interviews, focus groups, and observations from site visits on farms to collect qualitative data. We created data collection instruments, and set up meetings and site visits at farms depending on the availability of the farmers. Ing. Tencio assisted our research as a site visit coordinator, an intermediary between us and the farmers, an informational resource, and a guide to agriculture. Although his presence during farmer interactions may have yielded some bias in farmers' responses, the study ultimately benefitted from his knowledge, expertise, and relationships with the farmers.

We conducted sixteen individual interviews: five with farmers who use agrochemicals and eleven with farmers who use MM techniques. The purpose of these interviews was to gather and understand opinions of agricultural techniques, views on the MM trainings, and information about the social, economic, and environmental impacts of MM.

Along the same lines, we conducted five focus groups of five to ten MM farmers to collect similar information, as well as to obtain opinions and recommendations in order to improve the program. We observed the discussion to determine social interactions and collected farmers' opinions regarding the impacts of both agrochemicals and MM on agriculture.

During site visits, we observed the environmental conditions on the farm. After the first few farm visits, we developed an observation instrument to note indicators, such as crop quality, incidence of pests, and soil conditions on each farm. We documented observations through video recordings and photographs for later analysis.

From the data collected, we were able to draw conclusions via content analysis of the responses, opinions, and stories. We also used economic data provided by MAG to compare MM production costs to regional agrochemical averages. Findings allowed us to evaluate the efficacy of the trainings and techniques and to evaluate the impacts of the MM Program. From our conclusions, we recommend ways MAG can improve and expand the program.

FINDINGS

We analyzed data from the interviews, focus groups, and observations to evaluate the efficacy of the MM **trainings**, the efficacy of MM **techniques** and the social, economic, and environmental **impacts of MAG's MM Program**. To draw conclusions, we developed a definition of success for the MM Program, which encompasses both techniques and trainings. The program is successful if farmers correctly implement MM techniques taught by MAG and reap social and economic benefits while minimizing negative effects on the environment. Our findings highlight the successes of the MM Program, as well as opportunities for development.

Objective 2: Evaluation of the Efficacy of the Techniques

1. **MM Techniques improve crop quality and control pests when applied correctly**

Objective 3: Evaluation of the Efficacy of the Trainings

2. **The MM trainings are successful, but there is room for improvement**

Objective 4: Evaluation of the Social, Economic, and Environmental Impacts of the MM Program

3. **Soil is healthier when farmers use MM rather than agrochemicals**
4. **MM techniques are cost effective for farmers**
5. **Organic techniques present opportunities for innovation and entrepreneurship**
6. **Farmers experience development in personal and community relationships**

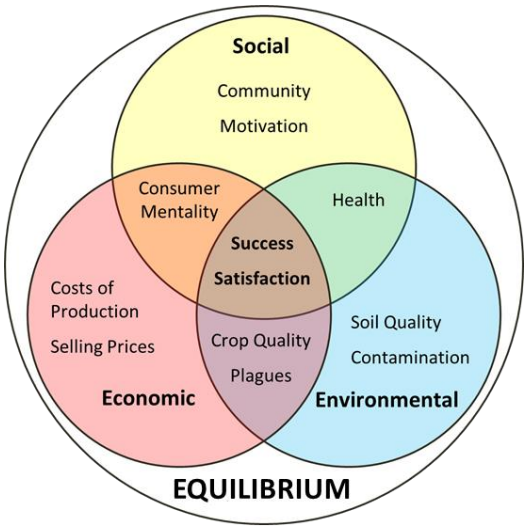

Figure 2. Interconnected impacts of the MM Program

Based on our findings, we have determined that the MM Program is effective and has positive impacts. To further characterize the interconnected environmental,

economic, and social changes taking place, we identified recurring themes like crop quality, health, and consumer mentality (Figure 2). Ultimately, program success and bettering of life stem from the equilibrium of environmental, economic, and social changes.

RECOMMENDATIONS

From these findings, we conclude that the MM Program is effective in its current state. We have also identified opportunities for MAG to augment the trainings, improve the techniques, and expand the program. The following recommendations stem from farmers' input and our findings.

There are opportunities to improve the Techniques.

Incorporate innovations from other farmers into the techniques trained. Since starting the program, farmers have been adapting the techniques to fit the needs of their farms. Since many farms across the region have different needs, we recommend that MAG incorporates these adaptations and innovations into the trainings, so that farmers can spread their knowledge to those who might be having similar ideas or problems.

Conduct further scientific studies about MM. Many farmers requested more information on the microbiology and the efficacy of MM. We recommend that MAG sponsor studies to determine which bacteria and fungi in the microorganisms function the best, as well as case studies of the evolution of soil quality on farms before and after they switch to MM. Using uniform soil tests will assist with both of these studies.

There are opportunities to improve and augment the Trainings.

Revise and expand the training instruction materials. The current instruction materials can be compiled into a detailed booklet with additional information, like 'recipes' for making MM and empirical scientific background. With this information, MAG will produce a cumulative manual that encompasses all the necessary theory to practice MM techniques. Additional materials will reinforce the PowerPoint presented in trainings, enabling farmers to continue learning at home.

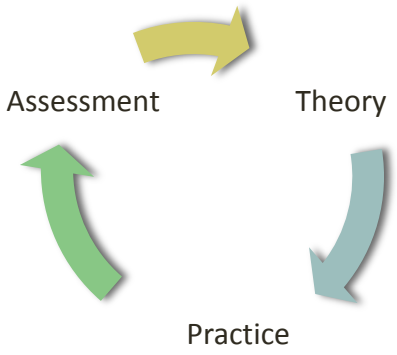

Figure 3. Proposed model for MM trainings

Increase the number of trainings and follow-up workshops. Many farmers reported that they would benefit from having further training sessions that involve

additional practice and assessment. As little as one extra training session could lead to a higher number of farmers who implement MM with confidence and sufficient experience. Our proposed model, which builds upon the current model, suggests a continuation of the three step model in a cycle, so that farmers are constantly learning (Figure 3).

There are opportunities to expand the reach of the MM Program.

Teach farmers to train other farmers. Currently, Ing. Tencio is the only person who conducts MAG's MM trainings. If the program grows, we recommend that MAG organize a workshop to teach farmers who have had success with MM to train other farmers in the organic techniques. Many farmers might be more willing to try MM if another farmer, who has success with the techniques, shows them the benefits.

Work with El Ministerio de Educación Pública to develop an organic agriculture program for public schools. We recommend that MAG start an educational program to teach children about organic techniques; thus the idea of sustainable agriculture can be instilled at an early age. Through educating the youth of Costa Rica, MAG can influence future generations to be more sustainable, to be aware of and protect the balance between people, the economy, and the environment.

SUMMARY

MAG's MM Program helps farmers restore natural balance to the earth from which they earn a living. Through this study, we evaluated the effectiveness of the MM techniques and trainings, and explored the social, economic, and environmental impacts of the MM Program as a whole. We conclude that the MM Program is successful, that farmers find it valuable and educational, and that MM can produce healthy crops to sustain the people of Costa Rica. Our recommendations for MAG present opportunities to expand and improve the program, through which MAG can further promote sustainable agriculture and improve the lives of farmers throughout Costa Rica.

1. INTRODUCTION

"Panza llena, corazón contento," is a Spanish phrase meaning "full belly, happy heart." While food is important in all cultures and societies, Costa Ricans, or 'Ticos' use this phrase to convey that food also provides nourishment and gathers people together around the table. In Costa Rica, a developing Central American nation pursuing sustainability, food links society, the economy, and the environment through agriculture. When sustainable, agriculture balances people, prosperity, and the planet, providing opportunities for a better quality of life.

Sustainable agriculture has environmental, economic, and social dimensions. Growing strong and healthy crops depends on the health of the earth. Farmers depend on crop yields to provide food and achieve economic stability. Equilibrium exists between the needs of the farmers and the environment. When one part is unbalanced, issues arise for farmers.

Sometimes agricultural balance is disrupted by seasonal and climate changes. Each season brings different plagues and pests that damage plants and threaten crop production. In order to ensure a profitable harvest, farmers fight to control pests by using harsh chemicals. Chemical pesticides, fungicides, and fertilizers are synthetic insumos, or products, that are applied to protect crops, improve their quality, and increase yields. However, just as bacteria develop resistance when antibiotics are overused, agricultural pests become resistant to agrochemicals over time. Agrochemicals must then be used more frequently in order to combat pests and plagues.

Over the past 30 years, Costa Rica has become one of the largest importers of agrochemicals in the world (University of Costa Rica, 2010). Between 1990 and 1994, the cost, insurance, and freight (CIF) value of pesticide imports increased from 56.2 million dollars to 84.2 million dollars or by about 50%. Imported agrochemicals degrade soil biodiversity and cause a decrease in the fertility and health of the earth (Gliessman, 1998). Soil quality deteriorates and organic matter is stripped away as fields are repeatedly cultivated (Gliessman, 1998). When the land is no longer able to support proper crop growth, production dwindles, and farmers lose revenue.

Agrochemicals are also expensive, and farmers who use them face high crop production costs. A 2014 economic report by our sponsor, El Ministerio de Agricultura y Ganadería, MAG (The Ministry of Agriculture and Livestock), showed that, agrochemical purchases account for 60-70% of crop production costs in Costa Rica's Eastern Central Region (Tencio, 2014). Farmers spend large sums of money to protect crops from pests, but are often unaware of collateral damage done to the soil and environment.

While using agrochemicals offers a time-proven way to earn a living in agriculture, a new global paradigm shift away from agrochemicals toward more sustainable techniques has arisen. Although organic techniques are readily available in Costa Rica's Eastern Central Region, many farmers are hesitant to try them and are wary of unproven economic results. However, with the help of government

agencies, like MAG, farmers can participate in trainings and find support as they experiment with new techniques.

MAG sponsors training programs and provides guidance and incentives for organic farming. In 2012, Ing. Rolando Tencio, an agronomist at MAG, started an initiative to teach farmers to use organic fertilizers and pesticides made with Mountain Microorganisms (MM). MM are bacteria and fungi sourced from decaying leaves in the forest. Farmers collect this decaying matter, mix it with water, molasses, and rice shells, and place it in an airtight container to ferment for fifteen days. Farmers use this mixture, called solid MM, to make various types of biopesticides and biofertilizers, known as *bioinsumos* in Spanish (Tencio, 2015).

MM *bioinsumos* enrich soil fertility and stimulate plant growth, thus increasing crop production by re-establishing microbial environments around plant roots (Joseph and Chacon, 2010). MM can be used to create multiple formulas that can be applied to crops to protect them from pests, produce more fruit, and allow them to thrive. MM's versatility and accessibility enable farmers to take economic stability into their own hands while maintaining environmental balance.

Currently, MAG teaches this technique in a three-step training program run by Ing. Rolando Tencio. The training includes sessions of theory, practice, and assessment. During the first session with farmers, Ing. Tencio introduces the theory behind MM through a PowerPoint presentation and a series of booklets and handouts. In the second session, he offers a practicum wherein farmers are taught to make various MM products through demonstration and active participation. This session provides an opportunity for farmers to complete hands-on learning through cooperation between the trainer and the trainees. In the third session, Ing. Tencio travels to each farm and assesses the implementation of the techniques by looking at the quality of the farmers' MM products and the quality of their crops.

Initially, the program started small, but it has since evolved to the three-step training process. Since the first training in 2012, Ing. Tencio has expanded the MM Program to reach over 200 farmers in the Eastern Central Region. Within the last year alone, he individually trained over 100 farmers. Between January and April of 2015, he trained 66 farmers and plans to train more.

While MAG monitors farmers' implementation of the MM techniques, the broader impacts on the farmers and the effectiveness of the program are not regularly assessed. Our study thus evaluated the social, economic, and environmental impacts of the MM Program implemented by MAG. The effects of the MM techniques and trainings were analyzed, assessed, and compared to traditional practices through interviews, focus groups, and observations.

We determined that the MM Program is effective. MM techniques can improve crop quality and control pests. The three-part trainings are successful because trainees enthusiastically participate and implement the techniques correctly. Furthermore, MM restores soil quality, reduces production costs, and reinforces community ties among farmers. MM sustainably reestablishes balance between society, economy, and environment. From our findings, we recommend six ways MAG can expand and improve

the program, introducing MM to more farmers throughout Costa Rica and to future generations. We hope that this report will find its way to the desk of Costa Rica's Minister of Agriculture, from where MM can become a widely-practiced technique used to maintain balance and improve life for people across the country.

2. OVERVIEW OF AGRICULTURE IN COSTA RICA

In the past, Costa Rica was known to be a top importer of agrochemicals (University of Costa Rica, 2009). Agrochemicals are chemicals used in farming as insecticides or fungicides to fight pests, improve crop production, and soil quality (Science Clarified, 2011). Recently, Costa Rica has developed high aspirations for sustainability. Due to the increased awareness of agrochemical usage, the agricultural sector of the government has been moving towards organic farming techniques to improve the health and wellness of both its people and environment.

2.1. BRIEF HISTORY OF AGRICULTURE IN COSTA RICA

Costa Rica has been an agrarian nation that has persevered through many technological, economic, and social changes. During the 1950s, the landscape of the country changed from dense forests to fertile fields cleared for farming and pasture (De Camino et al, 2014). Between 1961 and 1990, total agricultural production increased from 1.748 million metric tons to 4.915 million metric tons (Hall et al., 2000). Until the year 1990, agricultural goods comprised 72% of Costa Rican exports. A majority of the Costa Rican population based their livelihood either directly or indirectly on agriculture until the year 1995 (Hall et al., 2000).

2.2. RECENT STATE OF AGRICULTURE IN COSTA RICA

Agriculture currently provides jobs for 14% of the workforce in Costa Rica (World Factbook, 2014). Farmers produce crops and sell them to middlemen who bring the crops to consumers. This series is important for the economic wellbeing of the farmers. Sometimes there are two or three levels of middlemen, including those who package and process foods (Conversation with Tencio 2015). Through the exchange of goods down the series of middlemen, the cost of agricultural products rises. Farmers sell below market price, and consumers pay more for their food. If farmers had lower production costs and could sell produce directly from the farm, they would be able to earn higher incomes and have an improved quality of life.

Agriculture and the food industry have become commercial in recent years. Food imports increased by 170% between 1992 and 2005, and local food production has experienced a significant decrease over that time. Since the 1990s, agriculture's contribution to Costa Rica's gross domestic product (GDP) dropped from a high of 12% to 5.6% in 2013 (World Bank, 2014). According to Janet Page-Reeves, Ph.D., a professor at the University of New Mexico and expert on food security, the diminished amount of locally grown produce in the country has led to the necessary purchase of more expensive products from other regions. With the combination of urbanization and decreased food production, food security becomes a problem for those in low-income and rural households (Page-Reeves, 2014).

2.3. FACTORS THAT AFFECT AGRICULTURAL PRODUCTION

Agricultural production requires balance between the earth, economy, and people. To produce healthy food and good crops, farmers must care for the land it comes from. They rely on a successful harvest to earn a living. If crop quality or quantity is compromised, farmers struggle to achieve a stable income and good quality of life. The needs of the farmers and environment must be in equilibrium; when one part is unbalanced, issues arise.

Agricultural production can be unpredictable. Healthy crops require adequate water, nutrients, and energy. Crop yields and quality are affected by a multitude of variables including climate and plagues.

2.3.1. Climate

As with the rest of the world, global climate change has also greatly impacted Costa Rica. The rainy season brings heavy deluges and more floods, while severe drought threatens during the dry season (UNDP, n.d). According to the United Nations Development Programme (UNDP), Costa Rican agriculture must adapt to withstand the risks posed by unstable weather conditions (UNDP, n.d).

Climate directly affects crop production and quality. Crops depend on adequate sunlight and water in order to grow and produce. Temperature changes, drought, and increased carbon dioxide levels all adversely impact agricultural production (EPA, 2013). These factors vary seasonally. Costa Rica has two seasons, the dry season (November to April) and the rainy season (May to October). In the dry season, crops suffer from water shortages and heat damage. Farmers use irrigation systems to keep crops watered. Inversely, the rainy season brings a higher number of pests and plagues, typically insects, fungi, and bacteria that thrive in warm, damp conditions.

2.3.2. Important Agricultural Pests and Parasites

There are a number of common biological agents that threaten crop yields and lower the quality of produce from Costa Rican farms. These agents include various insects and fungi, which threaten crops throughout the country. In this section, we discuss the whitefly, the red spider, tizón, and nematodes. While these ailments are common in Costa Rica, this is not an exhaustive list.

A serious threat in Costa Rica is the *mosca blanca*[1] or whitefly (*Bemisia tabaci)*. The whitefly is an insect that infests tomatoes (Lotter, n.d), beans, zucchinis, eggplants, cucumbers, green beans, and the *chayote*[2] fruit (Pamphlet, n.d). The disease, which can cause discoloration to leaves and fruit, was reported in Costa Rica in 1996 and was named “el blanqueamiento” (Tencio Pamphlet, n.d). While

[1] Mosca blanca (Bemisia Tabaci) – a small homopterous insects of the family Aleyrodidae that are injurious plant pests. Whitefly is prevalent in the Eastern Central Region of Costa Rica feeding on the sap of plants covering them with honeydew (Merriam-Webster, 2015)

[2] Chayote – edible, light green fruit in the gourd family

feeding, the whitefly produces toxins and transfers a virus called *begomovirus* (Tencio Pamphlet, n.d). An investigation in Costa Rica in 1997 showed that 37% of beans, 22% of tomato and 9% of pepper were lost due to viruses transmitted by the whitefly (Anderson, 2005).

The red spider, known as araña roja[3] or Ácaros, is another prevalent pest in Costa Rica. The red spider provokes major problems in coffee plantations and strawberry farms around the country. It causes a reddish-brown discoloration of plant leaves that prevents photosynthesis, induces death of the leaves, and ultimately leads to the death of the plant (Delgado, 2013).

Pytophthora infestans, or *tizón,* is a fungus that causes a disease called *late blight* in potato and tomato crops (Uchida, n.d). *Late blight* thrives in cool, humid environments, and results in rotting light green, grey, or black, irregularly-shaped lesions on the leaves (Uchida, n.d). Ultimately, the rotting lesions penetrate the stem of the plant, causing death (Uchida, n.d). Today, *tizón* causes 20% yield losses worldwide (Federal Ministry of Education and Research, 2002) and can wipe out entire fields of crops (Barquero et al., 2006).

In Cartago there are many issues with nematode pests (Tencio, 2015). *Radopholus similis*, the toppling nematode, is found in banana, coconut, avocado, coffee, sugarcane, and citrus plantations (Lotter, n.d). This nematode causes lesions in plant roots, leading to malnutrition. These pests can prevented by cutting away dead leaves, removing weeds and overgrowth, cutting flowers at the proper time, and protecting the blossoms with bags (Lotter, n.d). However, these methods do not guarantee safety of the crops, especially if they are not implemented correctly.

Many more bacteria, fungi, insects, and mollusks affect Costa Rican crops. Due to the threat of pests and plagues across Costa Rica, many farmers turn to agrochemicals, specifically chemical pesticides, to protect and maintain crop quality.

2.4. Conventional Practices Used to Mitigate Threats

To combat threats from climate and parasites and protect crops, conventional agricultural practices were developed to maximize both production and profit. Common practices include monoculture, the practice of sowing only one crop in a field to allow efficient and high-yield cultivation; intensive tillage, using heavy machinery to overturn soil; irrigation, supplying water from reservoirs to hydrate fields; genetic manipulation of plants, artificial changes to DNA that enhance desired crop qualities; and the use of agrochemicals, to prevent pests and enhance soil nutrients (Gliessman, 1998). While these practices ensure stable crop yields in the short-term, they can degrade soil over time and cause collateral damage to the environment, reducing long-term crop health (Gliessman, 1998). This report

[3] Araña Roja – pest in the Ácaros taxon of arachnids containing mites and ticks. *Tetranychus urticae* included in this taxon is the red spider in the Eastern Central Region of Costa Rica. It is a prevalent insect pest causing leaf discoloration and death (Bayer Crop Science, 2013)

focuses on the use of agrochemicals, which includes the use of synthetic fertilizers and chemical pesticides.

According to the American Heritage Dictionary, agrochemicals are chemicals, such as fertilizers, hormone, fungicides, insecticides, or soil treatments that improve production of crops (2011). Specifically, agrochemicals are synthetic compounds produced in a laboratory for agricultural use (Conversations with Tencio, 2015). In contrast, supplemental minerals[4] are often used to enhance soil nutrients, but are not considered agrochemicals because they originate from a natural source. Agrochemicals are often sprayed on fields or piped to plants through irrigation channels. In general, they are applied directly to plants to artificially improve soil quality and eliminate pests.

One method of applying agrochemicals is *fumigation*, the release of gaseous pesticides into an area in order to kill crop-eating insects. The efficiency of fumigation is determined by temperature, duration of pesticide exposure, and quantity of fumigant used (Australian Government Department of Agriculture, 2015). However, fumigants are known to drift and contaminate the air in nearby communities and other agrochemicals have been found in natural and public water supplies. While agrochemicals enhance crop production, they have been shown to have negative long-term environmental, economic, and social impacts.

2.5. Adverse Effects of Agrochemicals

As previously stated, sustainable agricultural production requires balance between the earth, economy, and people. Over time, agrochemicals cause problems in all three areas. The following sections illustrate how the use of agrochemicals leads to environmental degradation, high production costs for farmers, and negative public health concerns. Ultimately, while agrochemicals have short-term benefits, they are unsustainable.

2.5.1. Environmental Effects

Farmers use chemical pesticides to control insects, fungi, and bacteria that harm plants and compromise crop yields. However, chemical insecticides, fungicides, herbicides, and nematicides not only kill pests, but also eliminate beneficial organisms (Pesticide Action Network, n.d). Harmful, or "bad" organisms are parasitic ones that eat leaves of plants, blemish crops, and ultimately decrease the quantity of production. Over time, these parasites can develop resistance to agrochemicals (Delgado, 2013). Beneficial, or "good" organisms promote crop health and augment productivity. Beneficial organisms include bees, butterflies, and other insects that pollinate plants; worms, which decompose organic

[4] Nitrogen, phosphorus, potassium, magnesium, manganese, boron, and sulfur are essential to proper biological functions in plants. Chemical soil tests typically assess the concentration of nitrogen, phosphorus, and potassium (N, P, K). When these are absent, farmers may add mineral powders directly to the soil or in mixtures with other chemical or natural products.

matter and return nutrients to the soil; and bacteria and fungi that convert nutrients into compounds that plants can absorb. Many "good" organisms are also natural predators of the harmful ones. When pesticides kill the beneficial organisms, ecological balance is disturbed and soil quality deteriorates.

While fertilizers supply soil with essential nutrients that enhance plant growth, they can leach out of the soil and into rivers and lakes over time. Fertilizers that seep into groundwater may present a health risk for dependent people in local communities. When they accumulate in bodies of water, fertilizers and pesticides cause *eutrophication*, the overgrowth of aquatic microorganisms when artificial chemicals build up in ecosystems (Gliessman, 1998). Eutrophication leads to algal blooms that compete for space and oxygen, once again disturbing the ecological balance.

2.5.2. Economic Costs

Global fertilizer usage experienced a tenfold increase from 1950 to 1992 (Gliessman, 1998). Between 1977 and 2006, Costa Rica specifically became the largest consumer of pesticides in the world as imports increased by 340% over 30 years (University of Costa Rica, 2010). However, agrochemicals are expensive, and their increased use poses an economic issue for small and medium-scale farmers. In the Eastern Central Region of Costa Rica, agrochemicals account for a large percentage of agricultural expenses (Tencio Report, 2014). In 2014, potato farmers spent 73.13% of total production costs (₡3,409,843 per hectare or $6,168 per hectare) on pesticides, fungicides, and insecticides. Other vegetable farmers that produce carrots spend approximately 59.2% (₡3,293,372 per hectare or $5,957.20 per hectare) of their total production costs on agrochemicals. For some farmers, these expenses compromise a large portion of their income (Tencio, 2014).

2.5.3. Social Effects: Health

Pesticides and fertilizers are present in the water we drink, the food we eat, and the air we breathe, making it difficult to avoid them (Toxins Action Center, 2012). Exposure to agrochemicals can cause a variety of adverse health effects, such as cancer, neurological and respiratory damage, and fertility issues (University of Costa Rica, 2010). Side effects of short-term exposure include nausea and headaches. Even low levels of exposure can have detrimental consequences. Agrochemicals can cause health problems for farmers and consumers alike; children are at a higher risk since their organs and brain are still growing and developing (Toxins Action Center, 2012).

Agrochemical and pesticide use can lead to many different types of cancer. Common types of cancer associated with pesticide use are bone cancer, brain cancer, and liver cancer (Toxins Action Center, 2012). In 2012, Costa Rica had the twelfth highest rate of gastric cancer, which occurs in tissues lining the stomach (International Agency for Research on Cancer, 2012). Gastric cancer correlates with ingesting produce treated with agrochemicals and has been the deadliest form of cancer in Costa Rica for the past three decades (Veerman, 2001). As more people encounter negative health effects due to pesticide usage, governmental organizations have begun encouraging changes to more sustainable practices.

2.6. El Ministerio de Agricultura y Ganadería (MAG) in Costa Rica

El Ministerio de Agricultura y Ganadería (MAG) is a government agency that promotes sustainable practices in the Eastern Central Region of Costa Rica and aims to protect and support farmers. MAG has had a strong presence in the agricultural sector for the past 70 years, helping local farmers improve crop yields and overall quality of life (MAG, 2014).

In the Eastern Central Region, MAG's mission is to promote and strengthen the efficiency, sustainability, and competitive edge of agricultural production in the region, allowing small and medium farmers to develop and integrate into the national and international market. In the Eastern Central Region, MAG provides the following public services to farmers (MAG, 2014):

1. **Technical assistance to small and medium farmers**
2. **Technical assistance to regional organizations of farmers**
3. **Local, regional, and national coordination with institutions to plan, implement, and monitor projects with farmers**
4. **Trainings for farmers in sustainable and organic practices**
5. **Registration for small and medium farmers in the agricultural sector**

MAG works with other companies and agencies in Costa Rica and around the world to spread knowledge and help farmers learn new agricultural techniques. In 2012, representatives from MAG participated in a program from the Japanese International Cooperation Agency (JICA) to develop a plan for organic agriculture methods. JICA is a government association dedicated to addressing global issues by providing security and assistance to developing areas and reducing poverty. In 2012, JICA created a workshop known as "Methodologies of Spreading Agricultural Organic Techniques to Support Small-Scale Farmers in the Central American and Caribbean Region" (Tencio, 2014). This workshop was held in both Costa Rica and Japan for three months. Each participant developed new plans for sustainable agriculture in their respective countries. Rolando Tencio, MAG's liaison for our project, is an engineer for MAG and was present at the JICA workshop. With JICA, he developed a program for MAG to teach farmers the use of Mountain Microorganisms (MM) in sustainable farming, a technique closely related to the more common Effective Microorganisms (EM).

2.7. Effective Microorganisms

Agricultural producers in various countries, including Japan and Costa Rica, have been utilizing a technique called Effective Microorganisms (EM) in organic farming for the past 30 years. Effective Microorganisms (EM) are a type of product created in the 1970s by Dr. Teuro Higa at the University of Ryukyus in Japan (Abdullah et al 2011). During the time of discovery, it was reported that a combination of about 80 different microorganisms were "capable of positively influencing decomposing organic matter such that it reverts to a life-promoting process" (Abdullah et al, 2011). The microorganisms used

in these batches stem from three families: photosynthetic bacteria, lactic acid bacteria, and yeasts (Condor-Golec et al., 2006). EM is produced in a liquid form and generally contains non-pathogenic microorganisms that may work to provide nutritional benefits and reduce the disease in plants (Condor-Golec et al., 2006).

There have been multiple documented cases of the effective application of EM technology. EM can be used for both agriculture and for environmental management (Abdullah et al 2011). In agriculture, EM have been used to treat several types of soils and crops. In a study by Sangakkara et al 2002, EM was shown to increase the release of nutrients, boost photosynthesis and protein synthesis, and improve the physical properties of the soil. EMRO, the Effective Microorganisms Research Organization in Japan, has had over 20 years of experience with EM, as they promote their use for safe and sustainable agriculture. They testify that when EM is applied accurately, decomposition of organic matter, recycling and availability of nutrients, nitrogen fixation, elimination of pathogens, solubilization of insoluble nutrient particles, production of polysaccharides and enrichment of soil microflora occur (Higa EMRO, n.d). EM is also used with livestock, as it has an antioxidant impact on manure, improving its odor (Higa EMRO, n.d). The same applies when EM is added to compost, reducing the poor odors and establishing growth of beneficial microbes (Higa EMRO, n.d). According to EMRO, EM can be used for water purification, cleaning in the household, preventative medicine, and in education (Higa EMRO, n.d). EMRO promotes the use of EM globally. They have “worldwide partners” in Costa Rica; EMRO Costa Rica with Universidad de EARTH in Limón and EM Producción y Tecnología S.A in San Juan de Tibas (Higa EMRO, n.d).

Scientific studies have yet to prove that the results from implementing EM provide all the benefits that Dr. Higa claims. In a 2006 study by Condor-Golec et al, the criticisms of EM’s effectiveness suggest a lack of studies and data to back up its efficacy. In fact, the study contends that a majority of the information about EM “has not been published yet or has been published in journals with a low impact factor.”

EM has inspired the invention and use of other organic techniques. However, EM is only one technique among many others that are used for organic farming. Mountain Microorganisms (MM) are the cousin of EM; the only difference is the source of microorganisms. EM is created in a laboratory from collected samples, while MM comes from the woods and mountains and is created on the farm. The training program MAG developed with JICA teaches farmers the use of Mountain Microorganisms (MM).

2.8. Mountain Microorganisms and MAG’s MM Training Program

Mountain Microorganisms are naturally occurring soil bacteria that can be cultured from decomposing organic matter sourced from local soil and cultured on a farm. MM is composed of over 80 species of bacteria and fungi across 10 genera that are responsible for decay. Such diversity of microflora mimics ambient soil conditions; healthy soils are characterized by diverse microorganism populations (Higa, 1998).

2.8.1. Mountain Microorganism Training Programs

In MAG's Mountain Microorganism Training Program, Ing. Rolando Tencio trains farmers to create home-grown organic fertilizers, pesticides, and other *bioinsumos*[5] that fortify and replenish the soil (Tencio, 2014, Report). The goal of the MM Program is that, by using MM techniques and avoiding agrochemicals, farmers can mitigate environmental contamination, reduce production costs, and improve social relations in the farming community.

The MM Training Program, inclusive of the techniques and trainings, has three stages: theory, practice and review. The program takes place over a three to four month period, one session each month. The three-step model is visually shown in Figure 1.

During the first session, Ing. Tencio teaches the group about the basic theory behind MM and other microorganism organic techniques. He introduces the techniques by presenting the history and the science behind MM, by talking about the successes that other farmers have had using these techniques, and by lecturing about the application of MM. An example of a slide from his presentation can be seen in Appendix B: . He also distributes an official handout published by MAG, so that farmers can try the techniques discussed at home, as seen in Appendix C: ..

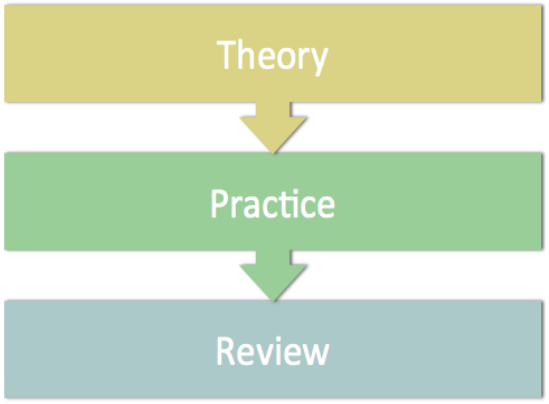

Figure 1. MM Training Three-Step Method

At the second session, Tencio provides review and materials to those who missed the first session, and briefly reviews the benefits of MM. After about a half hour, he walks farmers through a practical where they try to implement the MM techniques. Throughout the practical, he reinforces MM best practices.

During the third, and occasionally fourth, sessions, Ing. Tencio visits each farm that participated in the training and checks on their implementation of the MM techniques. He offers advice for improvements,

[5] Bioinsumos – products such as organic fertilizers and pesticides that are made from biological agents. When applied to crops, bioinsumos can be less costly and less harmful than conventional products. (Tencio)

such as “make sure the cover is secured tightly on the barrels,” or “apply biopesticides to the leaves instead of the roots.” This part of the training is individual, and usually occurs on the trainee’s farm. Sessions are repeated until he is confident in the farmer’s ability to perform the technique.

MAG's training materials include instructions for making and using 25 types of organic products based on Mountain Microorganisms some of which include *bokashi*[6], *apiche*[7], and *ortiga*[8]. These products support organic agriculture and cannot only be made from MM, but also complements MM.

MAG’s training programs teach farmers how to properly harvest MM and create *bioinsumos*. The time frame for the trainings depends on the schedules of farmers and is tailored to meet their needs.

2.8.2. Creating Mountain Microorganism Bioinsumos

Specific techniques to create mountain microorganism *bioinsumos* are taught and practiced during the trainings. There are two basic types of MM that are used to make the various *bioinsumos*: solid MM and liquid MM. Creating both types of MM begins with collecting the bacteria. Microorganisms are collected from soil on the forest floor because the forest is unlikely to be contaminated with chemicals and waste generated by people or industries (Tencio, 2014, Guide). Removing the top layer of non-decaying matter reveals actively decomposing leaves and branches underneath.

MM sólido (solid MM) is made by mixing 60 kg of microorganism-containing soil with one gallon of molasses or sugar and one 40 kg sack of rice shells. The molasses provide energy for the microorganisms to thrive, and the rice shells create the right consistency. Water is added to the mixture until the solution consists of 40% water. The mixture is put into a plastic 55-gallon drum and pressed down to eliminate air. The drum is then capped with an airtight seal and stored for 22-30 days. The bacteria and fungi multiply in this time, creating a “mother” culture from which other bioinsumos can be made. The solid MM will last at least one or two years. It is the principal form of MM and can be used in small portions to make liquid MM and other bioinsumos.

Farmers make MM líquido (liquid MM) by first making a “tea bag” of solid MM. A sack is filled with 8 kg of solid MM and used to inoculate a 55-gallon drum filled with 200 liters of water and 1 gallon of molasses. The barrel is sealed to prevent aerobic microbes (often pathogenic) from growing. The solution matures for 15 days, during which time fungi, bacteria, and yeast grow. Liquid MM can be applied to fields in a 1/18 dilute solution to control pests and accelerate the growth of plants and fruits. It has myriad other uses, such as facilitating germination of seeds, expediting compost decomposition, and improving digestion when applied to animal feed stock. Liquid MM sprinkled in chicken coops and

[6]Bokashi – Organic composting method that uses a mixture of microorganisms to accelerate decomposition by fermentation and reduce smells (Ketchum, 2013)

[7] Apiche – biopesticide originating from a mix of garlic, hot peppers, black pepper, liquid MM, alcohol and water. (Tencio Guide, 2014)

[8] Ortiga – biopesticide made from ortiga plant leaves, of the genus Urtica, MM, molasses and water.

stables eliminates odors. Finally, when mixed with various plants, minerals, worms, and organic materials, liquid MM is used to produce bioinsumos.

From solid and liquid MM, farmers can make *bokashi*, bioferments, biofertilizers, biopesticides and fungicides, organic mineral supplements, and different types of compost. The spectrum of possible combinations has yet to be fully explored, and MAG continues to learn new MM techniques farmers develop.

2.9. NEXT STEPS

Since these MM trainings started only in 2012, they have not been evaluated to a great extent, and their impacts on the people, livestock and crops are still uncertain. Many farmers are wary of committing fully to MM after MAG's trainings because conventional techniques are vetted and, as we've shown above, farmers face a difficult and uncertain harvest; however, they are open to change if it increases crop yields and decreases expenses (Interviews, March 2015). Though trainings have been ongoing for the past two years, the efficacy of the program and the social, economic, and environmental impacts of the MM trainings have yet to be evaluated.

3. METHODOLOGY

The purpose of this project was to analyze the efficacy and social, economic, and environmental impacts of MAG's Mountain Microorganism (MM) Program through interviews, focus groups, and observations conducted on farms. We also compared these impacts with those of agrochemical farming techniques in order to obtain a holistic view of farming practices and their effects. By learning and understanding about these practices we were able to evaluate the efficacy of the MM farming techniques and trainings. We also evaluated the social, economic, and environmental impacts of the MM Program. Through analysis of the results we developed recommendations to improve the Program in order to increase the acceptance and use of these sustainable practices.

In order to achieve the goals mentioned above we developed the following objectives:

OBJECTIVE 1: Become knowledgeable about agricultural techniques and trainings in Costa Rica
OBJECTIVE 2: Evaluate the efficacy of Mountain Microorganism techniques
OBJECTIVE 3: Determine the efficacy of the Mountain Microorganism trainings
OBJECTIVE 4: Evaluate the social, economic and environmental impacts of the MM Program

Since the objectives of our project intertwine, our methods overlapped. We determined that our articulation and presentation in this report should explain the unique format of our project methodology. The majority of the information we collected was qualitative and quantitative, social, economic, and environmental data, derived from interviews, focus groups, and observations regarding the MM trainings and techniques.

In Section 3.1, we describe the research we performed in order to become knowledgeable consultants for MAG and provide educated recommendations. In Section 3.2 we explain our preparation for and our procedures during on-site fieldwork. It establishes which methods we chose to implement, why we chose them, and how we enacted them. Finally, in Section 3.3, we analyze how each of the research methods we chose completed our objectives.

3.1. OBJECTIVE 1

Become knowledgeable about agricultural techniques and trainings in Costa Rica

In order to gain the knowledge necessary to become qualified consultants for MAG, we researched various topics related to agriculture and MAG's MM Program in Costa Rica. We used multiple types of sources to gather background information on different areas of agriculture. We conducted online research of books, journals, articles, and documents provided by MAG and found on their website. All of this research enabled us to understand the role and history of agriculture in Costa Rica, the development of new organic techniques, and Costa Rica's shift towards sustainability.

Ing. Tencio[9] was a continuous resource for information throughout our project. Prior to our arrival at the Costa Rica project site, he provided us with articles representing diverse perspectives on organic agriculture in Costa Rica and with overview information about techniques taught during MAG's trainings. Once we arrived in-country, he was a constant source of verbal facts, literature resources, and networking opportunities to meet farmers. We spent a great deal of time with him in the first two weeks and frequently discussed topics that were pertinent to the project and his work. We asked him to provide us with demographic and economic information on farmers in the area, the internal workings of MAG, and the use of agrochemicals, all of which we used in our analysis.

During the course of the study and through discussions with Ing. Tencio, we became aware of areas of knowledge that we did not consider during our initial research. With the help of Ing. Tencio, we tailored our research to learn more about specific pests that are prevalent threats to farmers' crops in the Eastern Central Region of Costa Rica. Additionally, he informed us about the relationship between seasonal changes in rainfall and increases in pest infestations that affect crop yields. With his guidance, we became aware of the significance of different color agrochemical labels and their resulting health implications. Discussions with Ing. Tencio were useful to clarify which crops were most common in the areas that we visited for interviews. Throughout the study, Ing. Tencio gave us direction to further research background information that filled in the gaps in our knowledge.

We noticed that the majority of our information about Mountain Microorganisms originated from MAG materials. To address this bias and look objectively at farming techniques and their effects, we consulted externally produced literature to gain deeper perspective on MM; we conducted research about the similar technique of Effective Microorganisms (EM). Through research on the complex process used to create EM, we learned that there is a gap in scientific research on the use of microorganisms in agriculture. There is simply not much published research on MM and we are among the first to conduct an analysis.

3.2. Data Collection and Fieldwork

We considered a number of different ways of collecting data to evaluate the social, economic, and environmental impacts of the MM techniques and MAG's trainings. Early on, we decided to use both quantitative and qualitative data to evaluate different dimensions of the impacts. Initially, we planned to use surveys, interviews, and focus groups as our main means of data collection. Surveys allow for a fast accumulation of data from a relatively large population and can be extremely useful in the evaluation of various conditions and circumstances (Berg & Lune, 2012). Interviews are useful when collecting participants' true feelings and perceptions and allow the researchers to acquire valuable knowledge directly. Similarly, focus groups are techniques used to collect qualitative information about people's thoughts and feelings. Focus groups are unique because, in contrast to interviews, they reveal

[9] Engineer Rolando Tencio was our sponsor and liaison to MAG. He is an agronomist at MAG.

the opinions of the group as a whole, rather than just the individual members. When facilitated effectively, focus groups can elicit poignant discussion and illuminate complex relationships between parties and points of view (Berg & Lune, 2012). This section details the procedures followed while preparing and conducting fieldwork and the rationale behind our actions.

3.2.1. Field Work Development

Despite our initial desires to conduct surveys, we thought it would be more practical to dedicate our time conducting interviews, focus groups, and observations. This strategy allowed us to meet the farmers face-to-face and gain more perspective on their personal experiences. These methods were most useful for our study because they provided insight into farmers' opinions as well a potential counterpoint based on our own observational skills. However, we realized that there were time constraints while completing our interviews, which is why we only interviewed a total of 16 farmers.

By using different techniques for data collection, we planned to triangulate information to be more confident in the validity of results. In triangulation of information, commonalities between results from two or more data collection methods are identified to draw conclusions and verify results (Berg & Lune, 2012). We decided to use both quantitative and qualitative data in the triangulation of information in order to verify results.

The following chart shows our plan for meeting objectives 2, 3, and 4 using data gathered through interviews, focus groups, and observations.

Table 1. Methods Used to Complete Objectives

Data Collection Methods	Objective	Information Gathered
Background Research	1	Information on farming techniques (agrochemicals and MM); information on MAG
Interviews	2	Training Satisfaction, Reasons for undergoing trainings, perspectives on trainings, Social Relationships
	3	Occurrences of Pests, Crop quality, Crop yields, Costs, Health of Soil, Enthusiasm of Farmer
	4	Pressures from family/friends, acceptance of MM, production costs, air and soil quality
Focus Groups	2	Emotions, Reactions, Interpersonal Relationships
	4	Pressures from family/friends, acceptance of MM
Observations	3	Number of techniques employed
	4	Pests, macroorganisms in soil

3.2.2. Interviews

Preparation

We decided that in-person interviews would be the main method of data collection. According to Berg and Lune, interviews require the researcher to take into account the sequencing of questions, effective communication, and the assessment of sensitive material. They provide an important social experience that allows the researcher to gain a better understanding of the participants' state of mind (Berg & Lune, 2012). We decided to conduct interviews in-person and on-site at farms to make the interviewees feel more comfortable, and we encouraged farmers to showcase their crops and methods. Such methods also allowed us to perform essential observations of the farmers' reactions and facial expressions.

The interview instrument evolved through multiple iterations before becoming finalized. One issue that we encountered during our drafting of the interview instrument was finding a way to ask farmers about social, economic, and environmental issues without creating offense or a lack of trust. Ing. Tencio and Ing. Omar Somarribas, another MAG employee with a background in agronomy and information technology, helped us craft questions to yield meaningful and quality answers, despite the language barrier. Ing. Somarribas encouraged us to revise the instrument and reduce the number of open-ended questions. We drafted initial questions in English so that we could deliberately tailor the meanings of questions on the interview instrument. After making changes and translating the interview instrument into Spanish, we met with Ing. Tencio to discuss every question in detail.

We developed two versions of the interview instrument, one tailored to farmers who use agrochemicals and one to farmers who use MM (see Appendices C and D). We decided that it was important to interview both types of farmers in order to obtain a holistic view on the farming techniques, the reason for using each, the farmers' opinions, and the effects of using the techniques.

Through iterations, we designed a structured interview where we predicted answers and turned open-ended prompts into yes/no questions. We hoped that having a structured interview would reduce the amount of time spent at each farm and provide us with a straightforward way to analyze the content of the interviews. However, there were costs and benefits to making these changes. On one hand, we were able to easily check off boxes, which facilitated data analysis. However, the structured interview did not allow for exploration through conversation and open-ended answers. As we engaged in interviews and implemented the interview instrument, we continued to discover opportunities to improve it. In practice, as described below, we implemented a semi-structured interview approach to acquire more personal information and relevant anecdotes from the farmers. Many of the questions for which we developed "closed" answers were met with responses we had not anticipated. After the first five site visits we reorganized the questions to have a more logical flow of topics and rephrased some for clarification. This revision allowed for the interview to become more of a conversation and to flow naturally, creating a friendlier approach.

We anticipated that the interviews might reveal sensitive and personal information. To ensure the security of this information, we created a consent form for interviewees to sign. The form states that we will not publish any data outside of the report, and that anonymity will be used in the case of sensitive material. Additionally, we asked permission to videotape and utilize the interview recordings for reviewing observations and making a video showing farmers' opinions of MM. The consent form can be found in Appendix G: .

Procedures

We conducted interviews with five agrochemical farmers and eleven MM farmers across a period of four weeks. With only seven weeks on-site, our interviewing period was limited to the first month to allow enough time for analysis. Ing. Tencio scheduled interviews, and we traveled by car to each farm on the day of the interview. Some farms were located far from Cartago and required a full day to travel, complete the interview, and return to San José. Additionally, the interviews typically lasted two hours or more and thus due to time limitations, we decided to conduct only five interviews with agrochemical farmers and instead focus on understanding the complex and varied experiences of MM farmers.

During interviews, all four of us were engaged and had defined roles. We conducted interviews in Spanish. Katie Picchione was the point speaker for most interviews and led the conversations. She also translated some of the farmers' key responses into English. Veroniki Nikolaki took notes using the interview instrument and ensured that all questions were answered as data was collected. She also took related notes to provide qualitative depth to quantitative responses. Kayleigh Sullivan took notes in a notebook to record other topics discussed and information revealed through the interviews, and she took pictures of noteworthy physical features of the farm. Kailey Castellano recorded video footage of interviews for later reference and took note of physical observations. The video recordings were used strictly to create a video for MAG and remaining clips were submitted to MAG with the farmers' approval. We handled the linguistic challenge of Spanish data collection in this way such that we could revisit the tape and review farmers' answers as well as our understanding. Together, the team was able to collect data in an effective way that triangulated facts stated, sentiments revealed, and observations made.

Ing. Tencio's presence at interviews ultimately had both pros and cons. His presence mediated relations with farmers, which allowed us to comfortably ask questions and feel welcome at the farms. During interviews, he was able to provide us with further explanations of unfamiliar words and concepts and facilitated when our Spanish skills fell short. However, his presence also may have led farmers to give slightly biased answers. Farmers may have been unwilling to offend Ing. Tencio by expressing their true opinions and experiences since Ing. Tencio had trained them in MM. Additionally, there were occasions during interviews when he clarified our questions, but in doing so, asked a leading question that might have shaped the farmers' answers. Ultimately, we decided that his presence was more beneficial than detrimental. With him present, we were able to establish relationships with the farmers and ensure our full understanding of their responses.

3.2.3. Focus Groups

Preparation

We hoped that the unique dynamics of focus groups would shed light on the relationships between farmers who have undergone trainings and their overall opinions of the MM techniques.

In order to create an effective focus group instrument we decided to include questions that had similar themes to our interview questions, but with more opportunity for open-ended discussion with the MM farmers (see Appendix H:). Though we were unable to hold focus groups with agrochemical farmers, since Ing. Tencio does not have as many connections with them, we successfully ran five focus groups with MM farmers.

In a similar method to the development of interview questions, we worked with Ing. Tencio to formulate and discuss the focus group questions. After we performed the first focus group, we decided that the order of the questions should be determined by the flow of the conversation to make it progress more naturally.

Procedures

We conducted five focus groups across a two-week period with farmers that use MM. These focus groups were either scheduled around one of MAG's trainings or scheduled specifically with a group of MM farmers. The five groups were:

1. **Farmers at APASVO (Asociación Producción Agrícola Sostenible Valle de Orosi)**
2. **Farmers that just underwent a biosalt training by a MAG extension agency in Dota**
3. **Farmers from Rio Conejo, Frailes**
4. **Farmers from the *Tigre* farm trained in August, 2014**
5. **Farmers in Copey currently undergoing MM training by Ing. Tencio**

The variety in these groups of people allowed us to compare the experiences of the first MM trainees who had only theory, those who experienced modified trainings with practical and assessment sessions, and farmers who have not yet had time to see the results of MM. Because of the farmers' limited time availability and the time-frame of our study, we were unable to schedule more focus groups.

During the focus groups, our roles were similar to the ones we had during interviews. The main difference was that we did not have a structured instrument for recording responses, so both Veroniki Nikolaki and Kayleigh Sullivan took notes. The notes were later compiled and reviewed with video recordings. Ing. Tencio worked as an intermediary for anything we could not understand or convey. His involvement in focus groups presented similar limitations to those experienced in the interviews.

A notable nuance of the focus groups is that some of the farmers were previously interviewed individually. There were both pros and cons to having familiar faces in the focus groups. The duplicate farmers already knew about our project and the intentions behind some of our questions. While they made the focus groups more comfortable, we got little new information from those we spoke with twice.

3.2.4. Observations

Preparation

Though we did not initially intend to use observations as a formal data collection method, we realized the value of articulating and systematically recording observations after the first few interviews. Initially, we made informal observations during interviews, as we tried to identify the factors at play and impacts of organic farming. While conducting fieldwork, researchers learn through observations, from perceptions, and adapt paradigms to plan next steps (Fox, 1998). As our interviews developed, we found that some of the observations we made fell into categories (e.g. soil quality, incidence of pests, and crop quality). We decided to formalize our process of making observations in order to assess people, situations, and impacts analytically and iteratively as we were immersed in interviews and data collection (Berg & Lune, 2012).

We created an instrument to formally record observations made on-site at farms. The observation instrument was drafted after the first five MM interviews. The final instrument can be found in Appendix I: . The raw data collected from the MM interviews can be found in Appendix J: . Observations from the first five MM and agrochemical interviews were recorded retrospectively using the video recordings, notes, and memory.

Procedures

We made observations primarily during interviews at the farms. We used a video camera, lens camera, and a notebook to record what we experienced. We made note of facial expressions, topics of excitement, and other strong sentiments the farmers portrayed. We also observed the physical setting of the farms, the soil quality, the type and health of crops, and noteworthy environmental conditions (e.g. the quality of water on-site) and recorded them using the observation instrument.

The recorded videos were used for later reference in the analysis of physical characteristics of the farm. Notes from the observations provided examples and support for data analysis. Also, they enhanced our empirical evidence with the addition of pictures or video footage that were useful in validating and verifying results.

The observation instrument addressed the following evaluation factors:

Soil Quality – We noted the presence of macroorganisms, the moisture of the soil, the color and the softness. These parameters were used to determine the health of the soil. We referred to advice from Ing. Tencio and Ing. Somarribas when evaluating soil quality.

Water Quality – Where possible, we observed the turbidity of water available on farms and farmers' irrigation systems.

Size of Farm and Crops Grown – We used this observation in conjunction with data on the number of types of crops grown. Biodiversity is a characteristic of sustainable farming and is included in MAG's trainings.

Passion and Motivation – We noted the topics about which farmers were passionate and looked for trends across farmers who had undergone trainings.

Time was the main limiting factor when making observations. Most of the time spent on farms was devoted to conducting interviews. Additionally, our observations were limited during the first interviews because we had not yet identified the factors we wanted to observe. Forming the observation instrument was an iterative process (see Appendix I:).

3.3. Objectives 2, 3, and 4: Evaluating the Impacts and Efficacy of the MM Program

Data collected through interviews, focus groups, and observations allowed us to complete Objectives 2, 3, and 4. These three objectives are closely related, but unique. For clarity, they are restated here:

Objective 2: Evaluate the efficacy of Mountain Microorganism techniques
Objective 3: Determine the efficacy of the Mountain Microorganism trainings
Objective 4: Evaluate the social, economic and environmental impacts of the MM Program

Objective 2 is to evaluate the techniques farmers use while Objective 3 specifically addresses MAG's trainings. Objective 4 compares the overall impacts of the MM Program, inclusive of both techniques and trainings.

The trainings and techniques have a complex relationship. These two parts of MAG's program build upon one another, but we consider them independently. In order for this program to be considered a success, both the trainings and the techniques must be effective. The program is successful if farmers implement MM techniques taught by MAG and reap social and economic benefits while having minimal negative environmental impact.

Furthermore, we defined "success" of the techniques and trainings independently. We consider the MM techniques successful if they maintain or increase crop quality and decrease the incidence of pest.

Comparatively, we define a "successful" training as one where farmers are able to later recall and properly implement the techniques taught.

There are two situations that can leave MAG's program lacking: MM may be an effective organic technique, but trainings could be subpar. Inversely, the trainings may be successful but scientifically, MM may not be an effective technique. Table 2 illustrates the relationships between the trainings, techniques, and program success. We used this table as a guide when making recommendations after achieving objectives 2, 3, and 4, as described in this section.

Table 2. Success and Failure Paths of the Trainings and Techniques

	Trainings Succeed	**Trainings Fail**
Techniques Succeed	Overall success of the MM Program	Partial success, improve trainings
Techniques Fail	Partial success, must improve techniques	Overall failure of the MM program

We studied the efficacy of the techniques independently of the efficacy of the trainings, and then evaluated the overall social, economic, and environmental impacts of MAG's MM Program on the lives of the MM farmers.

3.3.1. Objective 2: Evaluate the Efficacy of the MM Techniques

Objective 2 deals with the performance of Mountain Microorganisms. The main source of data for this analysis was from interviews and observations. We used several parameters to evaluate the effectiveness of MM techniques as we made observations during interviews at farms.

While we were present at the farms, we used the observation instrument to record indicators of success or failure with the MM techniques. We studied the plants and noted signs of pest infestation on the leaves and crops. We also recorded the quality of the fruit by looking at the size and color. The quality of the soil, including beneficial organisms, moisture, and softness, can also determine whether or not the MM is effective on the land. With photo evidence and notes, we were able to record these observations and analyze them later.

In order to understand if the techniques are applied correctly and thus are able to work properly, we took into account the personal observations and opinions of the farmers on their own land during interviews. Based on what they told us, we evaluated how well their crops grow, how healthy they are, and how content the farmers are with their crop performance. We also asked farmers about the prevalence of pests while using MM. This information helped us judge whether the techniques are effective for producing healthy crops.

3.3.2. Objective 3: Evaluate the Efficacy of the MM Trainings

To complete this objective, we evaluated how well farmers learn MM from MAG's trainings. We gathered and analyzed information about farmers' experiences, participation, and satisfaction during the trainings. We augmented our interview data with behavioral observations of interviewees. We also observed trainings by Ing. Tencio to understand and assess the methods used to teach the techniques. After the training we held a focus group with participants. By attending that training, we were able to see and learn through the eyes of the farmers participating. We discussed and recorded the following indicators and used the data gathered to draw conclusions.

Training Satisfaction - During the interviews, farmers were asked specifically whether they thought the trainings were conducted well and how content they were with them. These variables evaluated together allowed us to determine the opinions about the trainings. The responses of the farmers also allowed us to determine if the trainings themselves have been further developed and improved.

Training Perspectives – The interview questions also asked about the opinions of family members, employees, and neighboring farmers regarding the farmer's participation in the trainings. This information was analyzed to determine whether socio-political tensions and/or changes at the familial level arose as a result of the perception of the trainings. Questions also targeted the farmers' own perspectives of the trainings and aimed to illuminate how motivated they are to be involved. These perspectives not only aided us in evaluating the effectiveness of the trainings, but also gave us insight into the social dynamic fostered.

Training Participation – We recorded how engaged and motivated farmers were in the training process. We looked for specific aspects of the trainings that the farmers more eagerly embraced, if they asked questions, and if they accompanied the trainer in the making of MM and other bioinsumos. The amount of participation by both the farmers and the trainer dictated whether or not there was a productive learning environment.

Effectiveness of Training Method – MAG currently utilizes a three step training process that includes theory, practice, and assessment. We wanted to observe how well this process was implemented into the training sessions. During the theory component of the trainings, handouts and PowerPoints are used to enhance learning. These materials were also evaluated for clarity and efficacy.

By analyzing data of the statements of the farmers, across the board, we were able to create a holistic image of the trainings. Our presence at the trainings gave us a more reliable way to observe the efficacy of the trainings rather than only recording opinions of farmers. To augment our knowledge of trainings, we attended an alternative training hosted by the MAG extension agency in Dota. Participants were taught how to make a biofertilizer with natural salts. This training was not part of MAG's MM Program taught by Ing. Tencio, but did incorporate MM as an ingredient in the biosalt fertilizer. Observing a

different trainer teach different material gave us new perspective on the pros and cons of trainings that helped us draw conclusions about factors that make trainings successful and recommended ways that MAG can improve them.

3.3.3. Objective 4: Evaluate the Social, Economic and Environmental impacts of the MM Program

We evaluated the social, economic, and environmental impacts of the MM Program through interviews, focus groups, and observations. We compared information from agrochemical and MM farmers to determine whether or not switching to MM led to positive changes for the farmers. This allowed us to draw conclusions about the overall impacts of the MM Program.

Evaluation of Social Data

To evaluate the social impacts of MM, we explored the development of friendships, innovations and entrepreneurship, and relationships within the community. During focus groups we aimed to notice the dynamics of the communities of the MM farmers. We wanted to observe if the farmers gathered to share experiences and if they helped each other during the transition to MM. We investigated whether MM techniques were accepted among the community, if MM had negative connotation, and whether farmers felt pressure from their family or neighbors to use organic techniques. Interview questions and observations addressed these specific topics directly. The focus groups shed light on the communal aspects of the whole program since we were able to observe the interactions between farmers who had experienced varying degrees of success with the program.

Evaluation of Economic Data

Economics are extremely important in agriculture and farmers are hesitant to try new techniques when their conventional practices still appear to be working. They do not wish to put their entire livelihood in jeopardy by taking such a huge risk. We collected economic data from interviews and MAG's documents. This data included the number of kilograms of farmers' principal crops produced per year, the selling prices of crops and annual production costs. We compared economic data between organic and agrochemical farms, in order to determine if and how much less expensive MM is compared to agrochemicals. We also asked farmers whether they sold more crops since they started using MM.

Evaluation of Environmental Data

Environmental data obtained from MM interviews indicated whether or not soil quality improved since using MM. This information was gathered from verbal testimonies and our observations at farms. We observed the soil quality by examining the smell, feel, color, moisture, and presence of macroorganism in the soil. We compared these observations between agrochemical and MM farms to determine if there was in fact soil depletion from excessive chemical use. Ing. Tencio helped us learn what aspects and changes to look for in the soil. These observations allowed us to establish whether or not MM can lead to positive environmental implications.

We had intended to use soil analyses from different farms, provided by MAG and farmers. However, the data was incomplete and non-uniform. Some of the analyses were chemical and some were biological. The soil analyses could not be used to draw conclusions in this study.

4. DATA ANALYSIS AND RESULTS

Our evaluation of the Mountain Microorganism (MM) Program by El Ministerio de Agricultura y Ganadería (MAG) yielded results about the program's overall efficacy and social, economic, and environmental impacts. The findings from this evaluation are grouped into three main sections:

- Efficacy of the MM Techniques
- Efficacy of the MM Trainings
- Social, economic, and environmental impacts of MAG's MM Program

The findings in this report highlight the successful components of the MM techniques and trainings, the social, economic, and environmental impacts of the MM Program, and the opportunities for future development. Our results will lead MAG to understand the value of the program and its capacity to improve the lives of farmers throughout the Eastern Central Region, and ultimately Costa Rica. These results, in addition to the suggestions of the farmers, are the basis of our recommendations to MAG for the betterment of the MM Program. Please find raw data from MM and agrochemical interviews in Appendix H: Appendix I: respectively.

4.1. EFFICACY OF MM TECHNIQUES

New techniques, like MM, can impact farmers' quality of life. Farmers take a risk when they stray from the security of agrochemicals. To maintain economic stability, farmers must find that their income is unchanged or increased by using MM. In this study, we consider the MM techniques successful if they maintain or increase crop quality and decrease the incidence of pests. We used observations and interview questions to determine whether the techniques are successful for farmers who use them.

Finding 1: MM Techniques improve crop quality and control pests when applied correctly

We primarily used interviews and observations to assess the effects of MM on crop quality and pest incidence. At farms, we used the observation instrument to note the flavor and smell of fruit and visual evidence of pests. We held interviews at both agrochemical farms and MM farms to comparatively evaluate the effects of MM on crop quality and pest incidence. In each MM interview, we asked farmers a series of questions about changes in crop quality since using the new techniques. In many interviews, farmers were eager to show off the best qualities of their crops, such as the color and fullness of the leaves, the vibrancy and taste of the fruits. When asked questions regarding crop quality and pest incidence (listed in Table 3), most had positive responses.

Table 3. Interview responses to questions about crop quality and pest control

	Sí	No	No sé
¿Está contento/a con los resultados de MM?	**11/11**		
¿Los cultivos crecen mejor o con mejor salud?	**11**/11		
¿Los cultivos tienen un sabor diferente?	**7**/11	1/11	3/11
¿Se evitan los insectos y plagas?	**10**/11		1/11

One of the best comparative differences that we observed between agrochemical crop quality and MM crop quality was between two farms that we visited to complete our interviews. During an interview with an agrochemical farmer, who we refer to as Marco for confidentiality, we had the opportunity to observe a 1.43 hectare strawberry farm. Within the first two rows of plants, we noted that many of the leaves were brown, dry, and wrinkled, as in Figure 3; in contrast, others were a light or bright green. Off to the side, we saw several crates full of strawberries that were ready to be packaged and shipped. The fruit varied in color, ripeness, size, and shape. Many of the strawberries were small and deformed, and many of them still had white or light pink parts, indicating that they ripened unevenly. These strawberries can be seen in Figure 2. Although we did not see any incidence of pests in our short interview, Marco indicated that his crops had issues with red spider, and that in order to combat this pest, he used both green label agrochemicals and red label agrochemicals[10].

A week later, we visited a 100% organic farm that grew strawberries with MM. This farmer, Fernanda, had 9,000 strawberry plants on 0.17 hectares of land, and used MM with *lombricompost*[11], or worm compost, to make the soil for her plants. Additionally, she used other MM products as biofertilizers and biopesticides. When we first observed her farm, we saw that most of the leaves of her strawberry plants were bright green. The fruit were darker red than those we saw at Marco's farm. Those that were picked and ready to sell had more consistency in their color and ripeness. Most of the strawberries that we saw (and ate) were larger than Marco's strawberries. Her strawberries also appear in Figure 2 and Figure 3.

[10] The toxicity of agrochemicals is marked by a colored labeled: red is highly toxic, yellow must be used with caution, blue should be used with care, but is less toxic than yellow, and green is the least harmful.

[11] Lombricompost – compost made when worms decompose organic material. Most commonly, California Red Worms are kept in a dark container and fed with cow manure and other farm waste. Lombricompost is rich in soil nutrients and used in several applications with MM.

We observed that some of the plants were affected by Araña Roja[12]. When asked about it, Fernanda said that she had been using M5, an MM based insecticide, fungicide, and nematicide, on top of the leaves, but she had difficulty applying it to the underside of the leaves. Other than that, she reported that she does not have many pests. She noted that in general, "the M5 works well to kill the *chinchas*," another type of pest on her farm.

Figure 2. Agrochemical strawberries (left) vs. MM strawberries (right)

Figure 3. Agrochemical strawberry plants (right) vs MM strawberry plants (left)

By comparing the stories of these two farmers and our observations, we gained insight into MM's effects on crop quality and pest control. However, one of the most compelling stories of improving crop quality comes from a 75 year old farmer named Alvaro. He was trained in MM in 2014 and is still transitioning from using agrochemicals to MM on his 20 hectare farm of apples, plums, and avocados.

[12] Araña Roja – pest in the Ácaros taxon of arachnids containing mites and ticks. Tetranychus urticae included in this taxon, is the red spider in the Eastern Central Region of Costa Rica. It is a prevalent insect pest causing leaf discoloration and death (Bayer Crop Science, 2013)

During our interview, he excitedly explained that he now grew plums with MM alone and was testing the techniques on a portion of his apple trees. He went on to tell a compelling story about how MM improved the quality of a particular avocado tree. About a year ago, when he used only agrochemicals, one of his avocado trees was dying; there were no leaves and no fruit. His son wanted to cut down the tree that had stopped producing and plant two more in its place. Alvaro, however, decided to apply MM bioinsumos to the tree's branches and leaves, and to replace the soil around the tree with MM. The tree started to come back to life, he said, and was soon strong and healthy, producing large quantities of fruit.

We did not believe his story at first. When we saw the tree for ourselves, it had brighter leaves than some of the surrounding ones, and we saw plentiful avocados hanging from the branches (we were tempted to pick and eat them). Although some of the young avocadoes had a plague that turned the fruit brown, most of the fruits were dark green. Some pictures of the tree are shown below in Figure 4.

Figure 4. Avocado tree revived with MM

A critical point is that, while we conclude that MM controls pests, we also learned that it does not eradicate them. Many of the MM farmers still had pests on the farm, but, as seen in the stories above, they explained that they are no longer an issue. MM re-establishes equilibrium between parasitic organisms and beneficial organisms that promote healthy crop growth. As a coffee farmer in Dota said when we asked about holes found in the leaves of her plants, "The plants are for the birds and insects too—the plants provide for all."

When the crops are healthy, pests can exist without inhibiting crop yields. While some plants are affected, pests are held in check by their natural predators. Pests are only an issue when their natural predators are affected by agrochemicals. All coexist when MM is used.

By adding beneficial organisms like MM back to the ecosystem, pests are kept in check and crops flourish. From Maria's, Marco's, and Alvaro's stories and our observations, we determined that MM can improve crop quality and control pests when applied correctly.

4.2. EFFICACY OF TRAININGS

Finding 2: The MM trainings are effective, but there is room for improvement

The efficacy of the MM techniques is a direct result of the trainings' adequacy as well as the trainees' dedication to practicing them as instructed. This section reflects our findings from individual interviews, focus groups, and observations about the trainings. Our findings show that the MM trainings are effective, but there is room for improvement. We identified several factors that shed light on the effectiveness of the trainings, as described in the trends we detail below.

The three-part training enables farmers to implement techniques correctly

We determined that the Mountain Microorganism trainings performed by Ing. Rolando Tencio effectively teach MM techniques to farmers, empowering them to apply MM and have success. According to the Food and Agriculture Organization of the United Nations (FAO, n.d.), an effective training can have multiple styles of instruction, whether it is lecture, discussion, demonstration, or exercise; effective trainings should include the means for theory and practice. The 'theory' aspect of trainings, typically presented through lecture and discussion, is where an expert imparts knowledge in a way that is not only understandable to the audience, but also adaptable to time and space restrictions (FAO, n.d). 'Practice,' such as skill exercises or on-the-job trainings, can teach essential methods through hands-on experience and leave students comfortable with the material of instruction (FAO, n.d). By effectively utilizing both of these concepts, farmers are able to learn the basics of MM techniques and demonstrate their comprehension of making MM products.

To impart knowledge in the time available, it is important for a trainer to follow-up and provide trainees with the means to ask questions (FAO, 2015). Trainees can work through their implementation with trial and error and consult the trainer when they need help. By providing the resources and consultation, the trainer can ensure that farmers are implementing MM techniques properly, so that they can achieve the desired results for the production of MM product.

The objective of the MM training by Ing. Rolando Tencio is to equip farmers with the basic knowledge of the background and implementation of MM organic techniques. The trainings occur in three stages, typically three to four sessions held once a month. The trainings (1) introduces MM theory in the first session, (2) continues with a practical experience in the second, and (3) concludes with follow-ups to evaluate whether techniques are implemented effectively. We observed sessions two ("practice") and three ("follow-up") of the MAG MM trainings. Due to time constraints of this project and the training schedule, we were not able to attend the first session where theory is originally presented.

During assessment visits, Ing. Tencio can determine if farmers have implemented MM properly through indicators such as smell, feel, and presence of macroorganisms. An airtight container under some sort of shelter is necessary to cultivate the “good” MM bacteria and fungi in an anaerobic environment. There should not be any macroorganisms within the container. The MM should also have a sweet, fermented smell. While at the farms, we were given many opportunities to see the farmers’ personal batches of MM. We used the same indicators to observe for ourselves whether farmers had made MM correctly. The trainings have evolved slowly since 2012, and this knowledge helped us find correlations between farmers’ performance and how they were trained.

Most of the farmers we interviewed had created what we perceived to be “good” MM; however we did meet one memorable farmer from Turrialba whose MM products were not made well. We observed that his liquid MM had a rotting smell. Flies and worms infested the receptacle, though they should not exist if MM is properly made in an anaerobic container. Although our observations led us to believe that the MM was comparatively poor in quality, the farmer still felt that the MM had positive results with his crops. He continued to rave about the training he attended, a one-day training with over 100 participants. When we heard about the situation in which he was trained, we began to draw connections between the training method and a farmer's ability to implement techniques successfully. With only a few hours of training and no assessment, success is less likely.

To further illustrate the importance of the three-step process, we investigated two neighboring strawberry farms in Llano Grande. The owners of both farms are young women who participated in the first training held by Ing. Tencio in 2012. At the time, he taught only the theory behind MM. Both women attended the first training, but one of them, who we will name Elizabeth for the sake of confidentiality, did not have any assessment sessions, while Fernanda, mentioned in section 4.1, has been working closely with Ing. Tencio.

At Elizabeth’s farm, we made extensive observations about crop and soil quality. Though she was not present at the time of the visit (an extension agent from MAG invited us to the farm), we noted that her strawberry plants were dry, and many of the leaves were wrinkled and brown. Her soil had the consistency of sand and powder, and did not seem conducive to root health. Her fruits and vegetables were small and lacked a strong color. We found a dead insect in the soil as well. It was clear that she used agrochemicals. We later learned that she had only attended one ‘theory’ training and did not have any assessment sessions.

Conversely, Fernanda showed us her thriving strawberries. As described in Section 4.1, the leaves of her plants were bright green. The soil had a dark brown, earthy smell, and it felt loose and moist. Her strawberries were large and red, some as large as golf balls. She showed us the many different ways that she applied MM products, including her lombricompost, and raved about how well they worked with her crops. After further investigation, we learned that Fernanda has at least two follow-up visits from Ing. Tencio per month.

These two neighboring farmers, who had the same initial theoretical training, chose different paths, and ultimately had different levels of success. Elizabeth only participated in the theory session of the training, which in 2012 was the only one available, and three years later she still has not implemented the MM techniques, uses agrochemicals, and has struggling crops. Fernanda continued to receive follow-up from Ing. Tencio, so that she could practice the ones she was taught and get feedback, and ultimately she has maintained using MM techniques. These techniques have led her to financial stability, discussed further in Section 4.4.

This three step system of theory, practice, and assessment is a powerful training system because it not only engages farmers in different ways, but it also keeps farmers working on the technique for an extended period of time that allows for the necessary "prueba y error"—trial and error—that many of our interviewees mentioned. The additional sessions enhance the learning experience and improve understanding. Farmers who have experienced the best results from application of these techniques have experienced this three part system, and have had opportunities to learn, practice, and review, even in a short amount of time.

Many farmers indicated that they wanted further training sessions for the sake of either learning more techniques or for reviewing the current techniques. For example, a farmer in one of the co-op focus groups suggested the integration of "refresher meetings, even when we are done." Another farmer from the first co-op focus group suggested that "it's always better to learn more and share the techniques that we are learning." This result is both a success and a "failure" because it demonstrates that the farmers are interested and engaged in the subject and applying the techniques, but the training is not providing enough practice and review to satisfy their needs or wants. In Section 6.2, we make recommendations for MAG to expand the program and cater to farmers' requests.

Farmers are engaged in the trainings and willingly participate

We had the opportunity to attend a training hosted by the MAG extension agency in Dota, where participants were taught how to make a biofertilizer with natural salts. This training was not part of MAG's MM Program taught by Ing. Tencio, but did incorporate MM as an ingredient in the biosalt fertilizer.

From the three trainings we attended and observed (sessions two and three of the MM program and the additional biosalts training), we were able to evaluate the differences in the trainings to identify best practices from each and make recommendations to MAG to improve the trainings. From these observations, we determined that although both trainings seemed effective at the time, Ing. Tencio's training had more powerful impacts on the learners During the Dota training, we paid careful attention to the behavior of the participants. We observed that a majority of the people at the biosalts training were standing in the background, disengaged, having unrelated conversations. We also noted that most of the active participants in the biosalts training were females; many of the males either stood in the back or stayed on their trucks to watch. This was a useful baseline to compare the level of participation in the MM Program training that we observed.

When we attended the training in Copey (session two), a key observation was that farmers were continuously engaged. As Ing. Tencio walked the farm's owner through the proper way to make many of the main MM products, other participants actively asked questions without prompt and helped make the MM products. At the end of the session, Ing. Tencio started a practical where participants created M5[13]. The farmers took turns stirring the mixture and preparing the contents. When they learned to make apiche[14] by using hot chilies, they worked together to cut up the peppers. During these trainings we noticed that farmers worked as a group. By the end, they were laughing and joking together. By working with one another they bonded over the techniques that they were learning. Even when not part of the action, they continued to discuss the techniques on the side. The high level of participation and engagement in Ing. Tencio's training indicated that trainees found value in the material.

The technical guide makes it easy to review the material; however, not all farmers remembered the correct methods

We found that the technical guide provided by MAG during the trainings is an effective resource that farmers can use to review the material after the trainings. All trainees are provided with a short technical guide that describes 25 insecticides, fungicides, herbicides, and fertilizers made with MM (see Appendix C:). This guide is a comprehensive informational packet that describes the materials, procedure, and applications of each technique that farmers can reference to review techniques. Many farmers were proud to show us their guides and demonstrate which techniques they had applied.

We found that farmers could benefit from—and often desired more— literature to learn more about the application of and science behind MM. For the purposes of this study, as stated previously in this section, we define a "successful" training as one where farmers are able to recall and properly implement the techniques taught. Although farmers often had a good grasp of how to make the solid and liquid MM, they often could not remember the names of specific techniques, or sometimes requested more literature about the science behind them.

We evaluated how well farmers retained information through interviews and focus groups. We investigated farmers' knowledge and understanding of the techniques after the trainings. During the interviews and focus groups, we asked, "What techniques were taught at your trainings?" From the eleven MM interviews, we determined that all of the farmers learned and remembered how to make liquid and solid MM, but had difficulty remembering some of the related techniques that were taught, such as ortiga[15] and apiche. Often times during this question, farmers said, "I don't remember the name

[13] M5- an MM based insecticide, nematicide, and fungicide made with garlic, hot peppers, onion, ginger, molasses, vinegar, alcohol, water, and liquid MM. This mixture is fermented for 15 days and then applied to crops to protect from various pests

[14] Apiche – biopesticide originating from a mix of garlic, hot peppers, black pepper, liquid MM, alcohol and water. (Tencio Guide, 2014)

[15] Ortiga – biopesticide made from ortiga plant leaves, of the genus Urtica, MM, molasses and water.

of this technique" or Ing. Tencio would try to help them remember what was taught. Ing.Tencio's intervention, though helpful to the farmers, posed a slight bias to our results because participants may have not have otherwise remembered which techniques were taught.

Farmers are satisfied with the trainings.

Overall, many of the interviewed farmers that have received Ing. Tencio's training of theory, practice, and assessment, have not only had success with making and applying the MM products, but have also been immensely satisfied with the training itself. During interviews, we asked farmers to describe their satisfaction with the trainings on a scale of very discontent to "Pura Vida." Although Pura Vida simply translates to pure life, it means so much more to the people of Costa Rica. It is a mindset, way of life, emotion, and happiness. Initially, we did not think to include "Pura Vida" as part of the scale, but after a few farmers provided this answer, we felt it was necessary to add. Four of the eleven farmers interviewed said that the trainings were "Pura Vida." Five of them said that they were "very content," and one said that he/she was "content" (see Figure 5). None of the farmers we interviewed said that they were unhappy with the trainings.

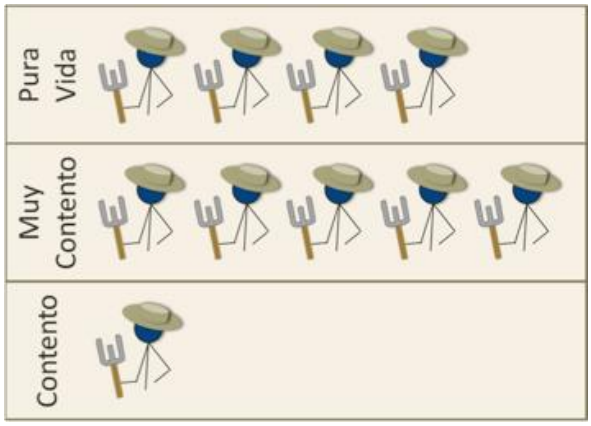

Figure 5. Responses to the question, "Describe your satisfaction with the trainings."

On the contrary, during the focus groups, many farmers spoke about how grateful they were to have the trainings and made recommendations and requests for more trainings. As one farmer, Gerardo, said during a focus group, "It's good to keep learning to grow things better! We are learning little by little and need to learn more techniques. Thanks to Rolando for all his work and support and help." In the same focus group, Berta, the president of the co-op said that she was "extremely grateful to MAG for the trainings." This demonstrates the training's and farmers' success, as farmers gratitude and interest to learn more shows that they are enjoying the process. While satisfaction is not a direct indicator of the efficacy of the trainings, there is a correlation between satisfaction and engagement, and between engagement and ability to implement techniques properly.

4.3. Environmental, Economic, and Social Impacts of MAG's MM Program

In order to understand the nuanced impacts of MAG's MM program, we identified five main findings, discussed below, that characterize the interconnected environmental, economic, and social changes taking place. Figure 6 highlights recurring indicators of environmental, economic, and social developments, and shows the overlap among themes like crop quality, health, consumer mentality, and the bettering of life. Ultimately, program success and bettering of life stem from the equilibrium of environmental, economic, and social changes.

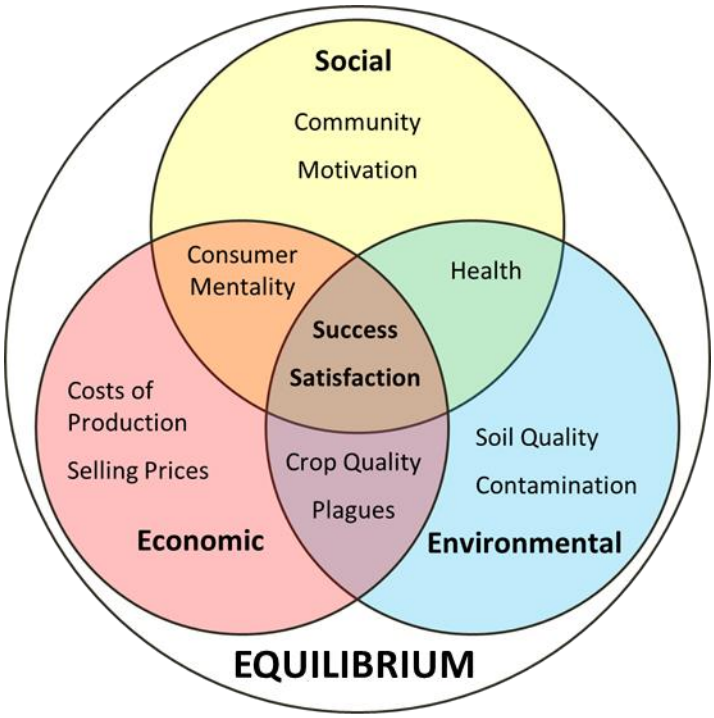

Figure 6. Venn diagram of the environmental, economic, and social impacts of the MM Program

This section progresses from a discussion of environmental impacts, to findings on economic feasibility, and finally conclusions about social changes that have stemmed from the MM Program. Throughout, we discuss overlapping environmental, economic, and social themes within the context of the five main findings.

Finding 3: Soil is healthier when farmers use MM rather than agrochemicals

Healthy crops grow from healthy soil. When fields are left fallow, unsown, and unmaintained, organic material collects in the fields, decomposes with the help of beneficial microorganisms, and replenishes soil nutrients. However, when crops are grown continuously and shipped off the farm, nutrients are depleted from soil over time. When agrochemicals are thrown into the mix, many beneficial microorganisms are killed as well as the bad, and soil nutrients cannot be replenished. Farmers of all ages can see the results from this common process in agriculture. "The soil becomes tired after many years, and it erodes due to excessive use of agrochemicals," as one 18 year-old coffee producer from Dota puts it. Despite his youth, this productor explained that those who have grown coffee for many years know how to reap a harvest but still see reductions in yields over time. The quality of soil deteriorates when agrochemicals are used long-term and fields are cultivated unsustainably.

Our findings show that using MM not only improves crop quality with the reduction in pest incidence, but also enhances soil health by preventing environmental contamination from agrochemicals. Furthermore, there is evidence to suggest that MM actively restores health and cultivability to soil that has been damaged by agrochemicals, thereby improving soil quality.

Soil quality is determined by physical, chemical, and biological indicators (USDA, 2008). There are tests for each type of indicator that can be used to assess the soil health and quality. Some examples include bulk density measurements, nutrient concentration measurements, and organism identification. Due to limitations of time, resources, and evolving knowledge, we were not able to administer any of these tests because of the broad reach of our study.

Since the few chemical and biological reports we had access to contained inconsistent measurements, we could not utilize them in our soil analysis. Throughout our study, however, we were introduced to various soil properties through experience. We identified soil quality based upon what we could see, touch, and smell, which together encompass physical and biological indicators. Additionally, farmers indicated that they had previously commissioned soil tests to determine which chemical nutrients were lacking and thus be able to apply salts to the soil, a process we will discuss below. We evaluated the differences between soil treated with agrochemicals and MM and the effects of MM on soil quality by (1) inspecting and observing the soil on the farms and (2) asking farmers for their observations of their soil quality.

One of the indicators we encountered was the looseness and physical quality of soil. Based upon our experience, healthy, high-quality soil was usually characterized by a dark color, mild earthy fragrance, and moist texture. In contrast, unhealthy soil was dry, either odorless or acrid, and felt like powder or sand.

An indirect indicator we observed is the farmers' use of salt on their crops. Often times farmers would indicate that soil tests that they performed suggested which minerals and nutrients they needed to add to their soils. Essential nutrients, including nitrogen, phosphorus, potassium, magnesium, manganese,

calcium, and boron, are essential to cultivating crops. Plants thrive when they can absorb adequate amounts of nutrients through their roots.

The presence of macroorganisms, including small plants (weeds) and a vast diversity of insects, indicate that the soil is healthy. The weeds help prevent erosion as their roots retain moisture and hold soil together. When these plants and insects die, bacteria and fungi decompose them and return nutrients to the soil. Additionally, we noted the presence of wildlife in the area, which is an indicator of the necessary organisms to start a food chain. If the crops are thriving, there should be beneficial bugs, like bees, and other macroorganisms. If there are bugs, there should be birds and other wildlife to feed on them.

Throughout our visits to farms, we found that the farms that use MM had less characteristics of unhealthy soil than those who used agrochemicals. Soil on the MM farms contained many macroorganisms including beetles, worms, and ants. Wildlife is abundant on farms that use MM and other organic techniques. The fields are filled with bees, birds, butterflies, and other animals (See image X). The presence of these animals indicates that there is very little contamination on the farm, if there were harsh chemicals being used there would be a lack of life. The beneficial insects like bees that that now have a higher presence have an important role in the success of many crops on farms.

Many of the farmers had weeds and nitrogen fixing plants around their crops. Some of the farmers were using salts to restore balance to the nutrients that had been unbalanced by previous use of agrochemicals, and, as such, their soil had many characteristics that indicated an increase in soil health. Examples from farms in Llano Grande are visualized below.

Our observations of the health soil in MM farmers were confirmed by many of the MM farmers reports. One example, mentioned in section 4.3, was Maria Ramirez. On her farm, we observed that her soil around the coffee plants had small plants on the ground soil around the crops. We also observed a multitude of macroorganisms, such as beetles and ants, which indicated her soil could support life. During our interview, she reported that organic techniques had benefitted her soil, and ultimately her crops. Approximately 20 years ago, she decided to switch from the use of agrochemicals to the use of organic techniques to maintain her crops. She reported that her soil took 15 years to fully restore the quality of her soil to yield these results. She showed us her compost pile of soil that she uses to create MM and other organic products, and we were surprised to see millions of ants crawling about. She reported that these organisms would not be present if she had not made the switch 20 years ago.

In contrast, the soil at agrochemical farms, observed during interviews, was devoid of life. We visited three agrochemical strawberry farms, one belonging to Elizabeth, and the others were owned by two unnamed male farmers. All three of these farms had little indication of macroorganisms, had dry, dusty soil, with either an odorless or acrid smell. On Elizabeth's farm, dust billowed with every step we took.

Evidence to suggest the restorative activity of MM

The restorative results of MM do not happen immediately. The negative impacts resulting from agrochemicals take time to diminish and the environment takes time to heal. Although it does take time, the farmers are still able to observe and feel the differences in their land and crops. All farmers seemed to react in a positive way when asked about the ways that MM has affected the condition of their land and produce.

An ongoing concern for organic farmers is contamination from agrochemicals used by neighboring farmers that are carried by wind and water. The soil is depleted of its natural nutrients and the air surrounding the farm gets filled with harmful chemicals. Fernanda from Llano Grande reported that before she made the change to MM, SFE (Servicios Fitosanitarios del Estado) conducted a soil analysis that showed her soil was greatly contaminated with agrochemicals. After making the switch, she reported that her resulting soil tests indicated that there are fewer chemicals in the soil; however, she mentioned that some of the agrochemicals from her neighbor's farm could have spread through the air and reached her crops and soil. She also reported that she had to plant trees between her farm and Elizabeth's farm in order to prevent the agrochemical contamination. By using MM and other organic techniques like biodigesters, Maria feels and experiences an extremely healthier soil.

MM replenishes the majority of these qualities when applied. The leaves on MM farms are vibrant and healthy, the roots are strong, and the soil is moist and contains beneficial organisms. The biofertilizers also renew nutrients and moisture in the soil and allow for the reestablishment of insects and nitrogen fixing bacteria.

We have seen that MM can restore ecological balance to create environmental conditions in which crops flourish. Just as MM reestablishes the circle of life between pests and crops, it completes the cycle of nutrients by decomposing organic waste to provide for future harvests. Environmental health is essential to sustainable crop production and long-term socio-economic profits.

Finding 4: Using MM is cost effective for farmers

The stories farmers have told about their experiences with MM reveal that it provides a cost-effective way to cultivate crops. Some farmers are able to sell organic produce at increased prices; most have significantly reduced production costs by using MM. Economically, many farmers have found MM preferable to agrochemicals.

The economic impacts of the MM program depend upon the costs and sales of farmers' various products. Through interviews with the MM farmers and economic data provided by MAG, we were able to compare the MM and agrochemical farmers' economic experiences and draw conclusions about the economic impacts of organic farming with MM.

Profit,by its most simple definition, is the net difference between the cost of production and the selling price of goods sold. It can also be thought of as income minus expenses. For farmers, the expenses are

the costs of production: labor, pesticides and fertilizers, machinery and equipment, maintenance, etc. Income is the price for which farmers sell crops. Net profit is the money farmers make once expenses are paid off.

To determine whether MM is economically profitable, we attempted to analyze both the selling prices and production costs of organic and agrochemical crops. Due to time constraints, most of the data available was collected through interviews with farmers and from one financial report of total crop production in Cartago in 2014. The findings presented here are representative of the information we gathered, but further research may reveal more universal trends.

Our findings showed that there are discrepancies among farmers over whether MM crops sell for more money than crops grown with agrochemicals. During interviews, we asked farmers two questions related to crop prices: (1) do you sell more crops because they are organic? (2) has the selling price changed since you began using MM? Figure 7 below visually displays the results. Unfortunately, the sample size was small and the data is inconclusive. Therefore, we investigated other ways of finding out whether crops grown with MM sell for more.

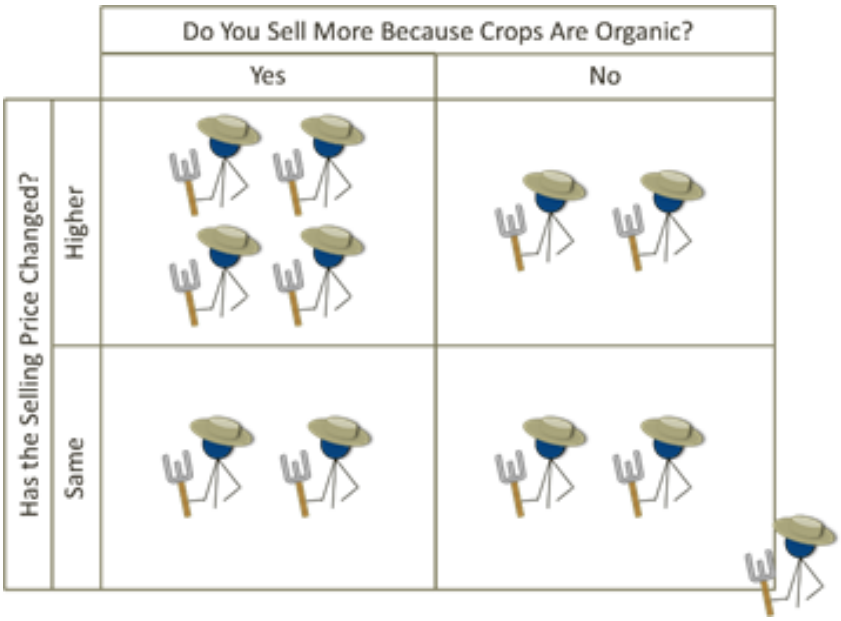

Figure 7. Farmer's Responses to Questions About Selling Organic Crops

The two questions were (1) Do you sell more crops because they are organic? (2) Has the selling price changed since you began using MM? Of the eleven farmers interviewed, one was ineligible to answer because he does not sell his crops (instead he gives them away to the needy). Six out of ten (6/10) reported that the crops do sell for more because they were organic, while four out of ten (4/10) said there was no change. Six out of ten (6/10) reported higher selling prices, while four out of ten (4/10) said the price was the same. There was a loose correlation between those who said they sold more and

those who said the price was higher, but overall the data was largely inconclusive. There were also no noticeable trends related to age or gender demographics with respect to profit margins.

However, the Food and Agriculture Organization states that worldwide, there is a specialized market for organic produce that often sells for more money. The question arises, if organic produce can be sold at a higher price, why are all farmers not certified? Maria Ramirez, a 46 year-old coffee farmer from Dota, explained that the process to become a certified producer takes several years and is expensive. A study comparing the profitability of "stratified organic" and "conventional" coffee farms in Costa Rica confirms that it costs farmers over $300 to become a certified organic producer (Lyngbaek, 2001). Additionally, organic insumos are costly and do not yield as high crop yields. For this reason, many farmers who choose to produce in sustainable ways may forgo organic certification. Incidentally, none of the farmers we interviewed are certified.

When farmers practice organic techniques without organic certification, the lines between "conventional" and "organic" farming become blurred. We were initially concerned to find that six of the 11 MM-trained farmers interviewed still use agrochemicals. All of them understood the severity of using agrochemicals, particularly those with a red label, indicating high levels of toxicity, but reported that they need to use agrochemicals on occasion to kill persistent plagues. By way of juxtaposition, two of the five untrained "agrochemical" farmers reported using organic pesticides and fertilizers like Dr. Obregon[16] on 70% or more of their crops. Four of the five (4/5) acknowledged either economic or social pressures to change to organic; three expressed interest in learning more about MM. One untrained farmer explained that he would be willing to try organic techniques, but only in a small area since he knows firsthand that agrochemicals work. Both the trained and untrained farmers are hesitant to fully commit to MM because they know that they will be able to earn consistent and time-proven living using agrochemicals. From this data, we concluded that the transition to organic techniques is a process. Economically (and socially too), it does not make sense for farmers to change overnight and risk their livelihood. However, the impetus to adopt organic techniques exists.

Farmers who produce non-certified organic crops are not guaranteed to sell at a premium price, but have other financial advantages. According to the FAO, while non-certified organic food is generally sold at the same price as conventionally grown crops, "some cases have been documented where non-certified organic agriculture increases productivity of the total farm agro-ecosystem, and saves on purchasing external inputs." MM is a fitting example. Currently, we do not have data to support further claims about the selling prices of crops produced with MM; however, our findings strongly indicate that low production costs create economic motivation to use MM.

MM is economically viable because it has little cost to the farmer, especially compared to agrochemicals. While agrochemicals are costly, MM is mainly made from materials found on the farm.

[16] Dr. Obregon is a line of organic pesticides and fertilizers developed by Dr. Miguel Obregon in Costa Rica.

Rigoberto, a plantain and coffee farmer from Turrialba, explained that after switching to MM, he saves tens of thousands of colones. A 55-gallon barrel of liquid MM costs him approximately ¢3,000; an equivalent barrel of agrochemicals costs upwards of ¢60,000. While MM sometimes is applied more frequently, 20 barrels of MM could be produced for the price of one barrel of agrochemicals.

To evaluate overall savings, we attempted to compare the annual production costs of various crops between agrochemical and MM farmers. Many farmers who use organic techniques plant a variety of crops to preserve balance in the environment and simultaneously diversify their income. If one crop has a bad season, they still have a source of income from others. The diversity made it difficult to gather comparable data from farmers, and much of the data was unusable. However, we asked both MM and agrochemical farmers what types of crops they grow and the cost of production for their "principal" crops. We also referenced one of MAG's regional financial reports to obtain the annual production costs for conventionally grown crops (Tencio, 2014).

In Figure 8, we compare the costs of production of both agrochemical and MM crops in Costa Rican Colones to observe general trends. Though the crops available for analysis are not the same between agrochemical and MM crops, there is a clear difference between the costs of production. From the data available, the average annual production cost of agrochemical crops is ¢ 4,565,601.14, while the average annual production cost of MM crops is ¢ 61,400.00. On average, our data shows that the agrochemical crops are nearly 75 times more costly to produce than the MM crops—a staggering difference.

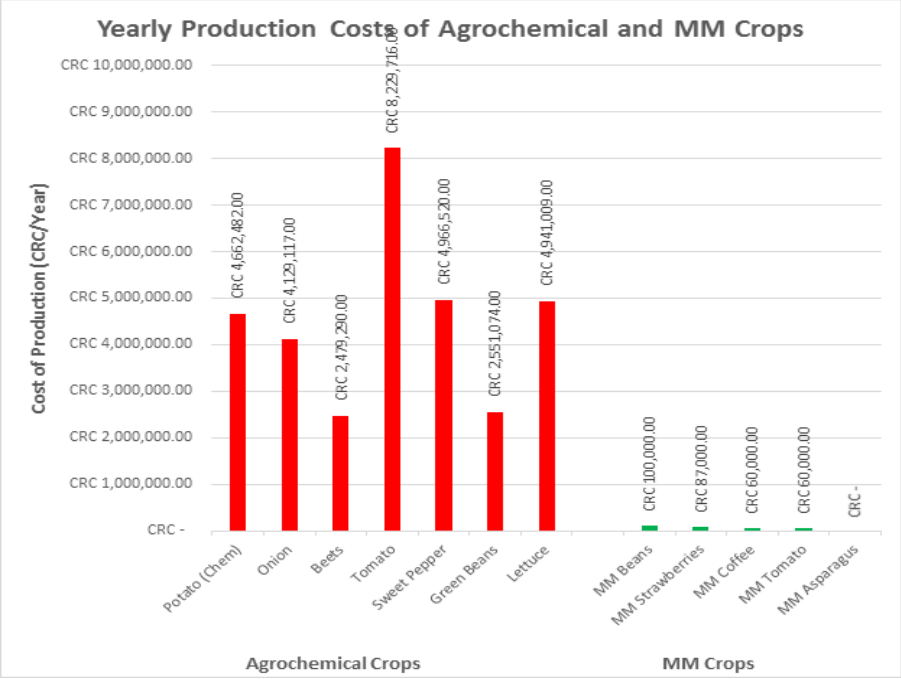

Figure 8. Yearly production costs of agrochemical and MM crops

To paint a more accurate picture of the reduction in production costs, we compared the cost of production of tomatoes and strawberries from agrochemical and MM farmers. Due to the limitations in our time and travel, it was difficult to travel to farms that had the same principal crop as listed in the baseline data provided by MAG.

Alfredo, an elderly farmer who grows tomatoes for charity using only MM, reported production costs of only ₡ 60,000 per year. We compared his experience to the average regional per-farm production costs of tomatoes grown on agrochemical farms, based on MAG's report, ₡ 8,229,716 in 2014. Figure 9 graphically compares these results. Alfredo's production costs are trivial compared to the regional agrochemical average.

Unfortunately we only had the means to compare these values on a per-farm basis. These data do not take into account differences in farm size and total crop yield, which was information unavailable to us.

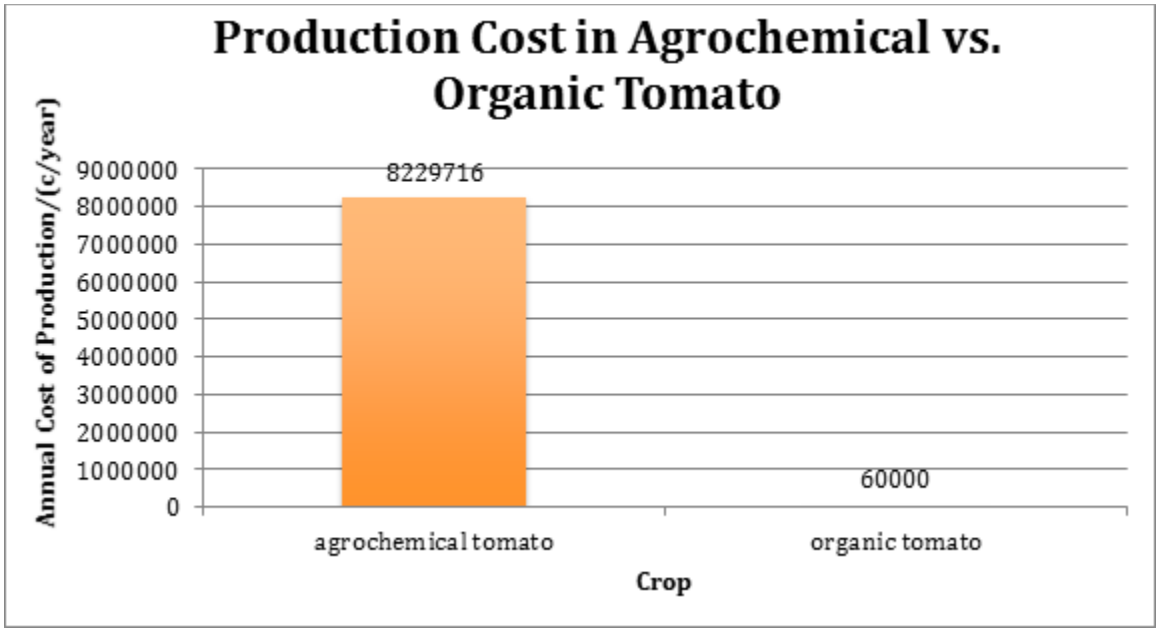

Figure 9. Production costs of agrochemical and MM tomatoes

The production costs for the tomato crop are significantly lower with the organic approach than those of the agrochemical approach.

We used the same approach to examine the annual production costs of the strawberry crop between the agrochemical and MM farmers. The main difference between these data and the previous data is that we collected these figures from the interviews we conducted from two agrochemical farms and from one MM farm. From the data, we observed determined that the production costs in a year are much lower when farmers use organic techniques. The agrochemical strawberry has a high cost of

production of ₡ 13,000,000-16,000,000, while the organic strawberry has a cost of production of ₡ 87,000. This difference is presented in Figure 10 below.

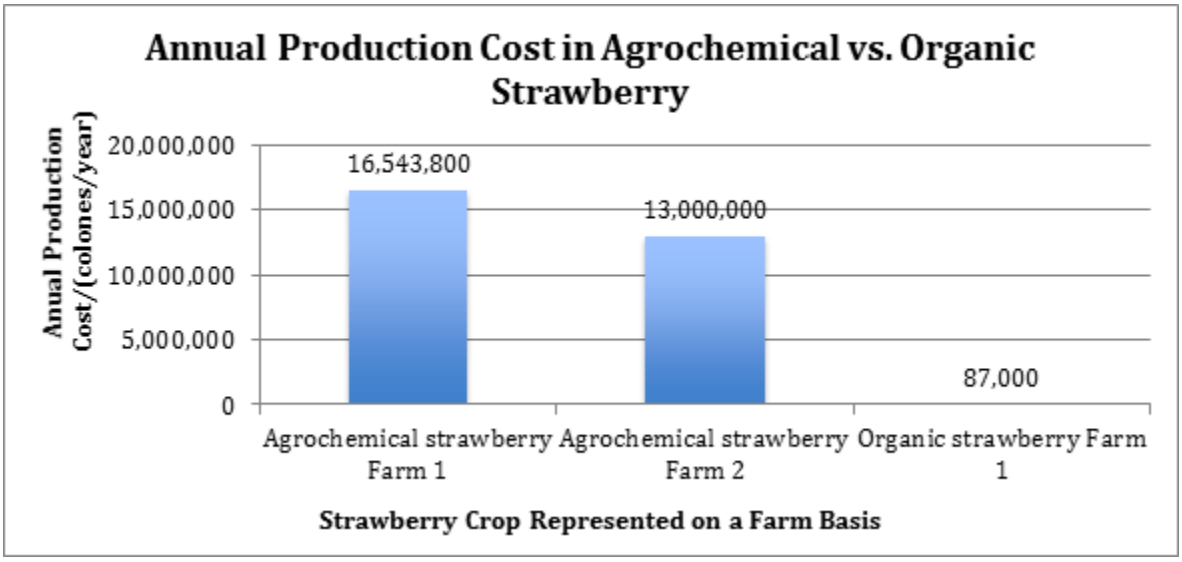

Figure 10. Annual production costs of agrochemical and MM strawberries

Clearly, there is a significant difference between the annual costs of production between the agrochemical and organic strawberries. The percentage decrease in costs between Agrochemical Farm 1 and Organic Farm 1 was calculated to be 99.5% decrease, while the percentage decrease in costs between Agrochemical Farm 2 and Organic Farm 1 was calculated to be 99.3% decrease. It can be observed that organic techniques have a significantly lower production cost than the agrochemical techniques.

After interviewing the organic farmers, we were able to determine if there was a decrease in their production costs after they switched from using the agrochemical techniques to using the MM techniques. Also, farmers stated that they had an average drop in production costs of 57% in the production costs once they changed from agrochemicals to MM techniques. The median for the decrease in the production costs was found to be 60% drop. But the production costs are only half of the story.

We conclude that, though our data about the selling price of crops produced with MM are inconclusive, MM is cost-effective and more financially viable than agrochemicals. The selling price is not as significant to the farmers because the production costs are so greatly reduced. By switching from agrochemicals to MM, farmers have more control over production costs and a wider profit margin between expenses and income. MM empower farmers to take financial security into their own hands.

4.4. ORGANIC TECHNIQUES PRESENT OPPORTUNITIES FOR INNOVATION AND ENTREPRENEURSHIP

Organic techniques open new innovative and entrepreneurial socio-economic opportunities for farmers. According to Merriam-Webster, innovation is the process of creating new methods, products, or ideas, and an entrepreneur is a person who starts a business. Through interviews and focus groups, we encountered many farmers who innovate with MM and organic techniques to make money.

It is not uncommon for farmers alter the MM techniques and use them in new ways after going through Ing. Tencio's trainings. Since each farm has unique social, economic, and environmental circumstances, farmers tailor the techniques to meet their needs. We encountered two common areas of innovation: farmers modify the composition of MM bioinsumos using materials readily available on their farm, and develop new methods to plant and organize crops.

Many farmers experiment with the composition of their MM bioinsumos and combine techniques learned from other trainings and farmers. In an interview held with Ruben at Finca Tigre, we heard a story about a farmer near Volcan Turrialba who had tried using volcanic ash in MM. The man had great success growing onions and potatoes with the combination. Ruben confirmed that the sulfur found in volcanic ash acts as a pesticide, while calcium, magnesium, potassium, and other minerals add nutrients to the soil for crops. A number of farmers we interviewed used varying types of ash, herbs, crushed rocks, and manure in their MM bioinsumos. They use whatever materials can be found on the farm.

Furthermore, Adrian, a coffee farmer in Dota de Tarrazú, an area known worldwide for producing high quality coffee, emphasized the importance of prueba y error, or trial and error, when developing the best MM fertilizers for his crops. He grows a variety of leafy greens in addition to coffee. Since learning MM in 2014, he has spent over six months testing different combinations of materials in bokashi. He finally found the right proportion of dried rice grain shells and coffee berry skins (left over from coffee production) to create a fertilizer that maintains the perfect moisture content and soil density for the leafy green plants. In using the coffee berry skins in bokashi to grow other plants, nutrients that are fixed in the skins of the coffee berries are returned to the soil from which they came.

Since using MM and bokashi, Adrian has been able to innovate new ways of planting his crops as well. Rather than growing plants in the soil of the earth, he cultivates seedlings in ~1 L black plastic bags with flat bottoms. Because the bags can be moved, small plants and big plants can exist in the same area, which increases the yield per area of arable land. The bags also allowed him to reduce his water usage by half since the plastic retained the water better. He can also take whole plants to market and sell them live. Economically, the plastic bags are nearly free, since several thousand bags can be purchased with the sale of one plant. For Adrian, this innovation came to fruition because his bokashi provides adequate nutrients and soil consistency for plants to grow in bag.

An intriguing finding is that Adrian is not alone. Bags or other containers are used at no less than five farms we visited, located in different corners of the Eastern Central Region, and each farmer had his or her own twist on the technique. For example, Nuria, a farmer at APASVO, had success using plastic bags to grow peppers and tomatoes on top of land that was too dense for growing crops. She placed bagged plants in a trough lined with plastic, as seen in Figure 11, and poured water into the trough to conserve. Each bag had small holes in the bottom to allow water to percolate in. Again, the bags were filled with bokashi and treated with MM bioinsumos. She took pride in showing us the liquid MM and M5 made at APASVO.

Figure 11. Nuria's tomato plants growing in plastic bags

Several of the innovative farmers we met are also entrepreneurial. During interviews, we learned about integrated farms, farms that use waste in every way possible to sustainably produce crops. Integrated farms generally have a wide variety of crops and livestock that create system where the crops feed the animals and the waste from both the animals and the plants are used to grow crops. Integrated farms recycle nutrients to help maintain soil quality.

Gudikaho, a farm in Pejibaye, is one example of an integrated farm that innovatively combines MM with other organic farming techniques. The owner, Rosa, grows a wide variety of fruits and vegetables, has a small fish farm, and holds livestock. She uses a biogas digester to anaerobically ferment manure and other organic waste to create methane gas, which can be used for cooking and nutrient-rich fertilizer. She also makes lombricompost, a type of compost made when the California Red Worm (*Eisenia fetida*) decomposes organic waste and renders the nutrients usable for plants. When used together, the

effluent from a biogas digester, lombricompost, and MM bioinsumos create nutrient-rich soil for plants to grow in. All three are made from organic wastes from the farm. The crops grown in this soil can be used to feed livestock, feed the family, and sell. Furthermore, Rosa also grows lettuce plants in vertical-hanging reused soda bottles and makes and sells MM bioinsumos in old soda bottles. She makes money through everything on the farm—waste and all—and even invites students to come for extended stays to learn about organic farming. She is exemplary, but is just one of the innovative entrepreneurs we met through our field work. Many of the exemplary innovators we observed had similar mentalities for improvement. Cross-referencing demographic data on the farmers who use innovative techniques, a trend was revealed: female farmers are proportionally more involved in innovative organic practices than male farmers. In the analysis, "innovative" farmers were identified as those who either used or expressed the intent to use biogas digesters, lombricompost, and/or novel potting techniques (e.g. bag-grown plants). Farmers who had or intended to have a model farm were also labeled as "innovative."

The sample size of women interviewed was small. Of the 41 farmers who participated in interviews and focus groups, 29 were men (70.7%) and 12 were women (29.3%). Of the women, 40% were identified as "innovative." In contrast, only 19.4% of the men showed innovative tendencies. Three of the women run model farms and host students. At least one of them aspires to do so in the near future.

While the sample size was small, these trends indicate that there is a correlation between organic farming and gender roles. Traditionally in Costa Rican culture, men are viewed as the breadwinners and women are expected to take care of the home (Massey et al., 2006). In the context of organic farming, however, we have seen a number of women in leadership roles on the farm. One group of farmers we visited had a female president. In contrast, no women were spoken to at farms identified as "agrochemical" producers. Though we do not have enough data points to make overarching claims about the relationship between organic farming and gender role, the data suggest that one or both of the following scenarios may be occurring:

1. **Strong, innovative women may be drawn to the opportunities organic farming presents.**
2. **The MM training program (and potentially other organic training programs as well) may be empowering female farmers to take control of their livelihood and assume leadership positions on the farm.**

Due to limitations on overall sample size of farmers we were able to reach in the time constraints of this project, further claims on these trends are outside the scope of this study. Future studies may find closer ties between the role of women and organic farming.

Many farmers have begun to apply MM in new ways in order to increase production and establish new sources of revenue by selling MM bioinsumos alongside produce. Farmers who apply organic techniques in entrepreneurial ways are not only increasing their income, they are changing their way of life. As farmers continue to create new formulas for and applications of MM, they open doors for economic

growth and social development. Entrepreneurial farmers may continue to find that organic techniques open doors for sustainable growth in both the social and economic realms while maintaining environmental balance and achieving improved quality of life.

Finding 5: Farmers report development in personal and community relationships as a result of the MM Program

Community development occurs whenever people interact and share new experiences. Farmers who participated in the MM Program described changes in relations within families, farming groups, and larger communities. This is not to say that communities were weak before the MM Program, but rather that the trainings have created new opportunities for community development.

Many of the farmers in interviews and focus groups reported that friendships and community was very important to the way their farms worked. Several farms had group harvests or family traditions about their normal, everyday harvesting and processing methods. For example, in the focus group in Rio Conejo, one farmer named Luis indicated that their process of splitting the coffee shells was a family event. Coffee is a well-known crop in this community, and they accordingly make the process of producing it a community-based project. Another farmer from the same focus group said that the process affects everyone: “The beneficiary is not just one person - it is the community. There are a lot of people who benefit from activities of coffee. It benefits not just one farm, but the workers, the family, the community.” This type of mentality, which was seen across the board in MM farmers, illustrates the importance of cooperation to serve the greater community.

Through focus groups, interviews, attendance at trainings, and other farm visits, we have witnessed close ties between farmers who practice MM and have undergone trainings. As explained in Section 4.2 on the satisfaction of the trainings, farmers developed friendships by participating in the training program. All but one farmer interviewed agreed that friendships had developed as a result of the training. Even when they were not trained at the same time, farmers reported that they developed stronger ties with neighboring farmers who practice MM. During the second focus group, several of the female farmers claimed that, though they had been trained at different times, they often ask each other for help with MM before reaching out to Ing. Tencio. These social relationships formed can be indicative of independence from the teacher. Also they show that farmers have reached a level of sufficiency to help each other. Additionally, the friendships could indicate an increase in trust in the other’s knowledge and capability with the trained techniques.

Several of the focus groups were held among neighboring farmers in collectives or on adjacent “parcels” of land that were established by the government or by private organizations. The parcels are nearby parts of land owned by multiple farmers who each works on their own land. These groups explain that they have experienced a particular strengthening of community as a result of the trainings. They come together to create MM, plant seeds, and work the fields. On one farm, they alternate weeks where they come together to plan and make bioinsumos one week and then plant the next. Farmers organize

activities around planning and planting. By planning and creating their bioinsumos together, they spend more time together. The prepping of bioinsumos gives them more face time with each other while collaborating. Two farms emphasized that they sometimes have parties and festivals or fiestas for sowing seeds and harvesting crops. These gatherings are very important to the farmers because as one of the producers said, “Pensamos en comunidad,” or “We think as a community.”

The sense of community has spread beyond the farms as well. One group explained that their collective relationship with a nearby village has also strengthened as a result of employing MM techniques. We were at first skeptical about whether this was actually a result of MM, but one of the farmers explained that, with MM, they spend less money on production but reap the same crop yields. There is more money in their pockets at the end of the day and they have plenty of food for their own families and, he claims, enough to even donate. Thus, by sharing crops with the town through donations and such initiatives, they have developed a new bond and a mentality that allows them to serve the community.

Throughout the course of this study, we, as researchers, also experienced the effects of the welcoming communities that have developed around organic farming. At nearly every focus group and over half the interviews with MM farmers, we were greeted with coffee, lunch, or fruit from the fields. Many of the MM producers were eager for us to try their organic produce and experience the difference. This hospitality was not found at the interviews conducted with “agrochemical” farmers. While some of the comfort may stem from the established relationship between Ing. Tencio and the MM farmers, every one of them welcomed us with open arms. Not only as researchers, but as people, we had the opportunity to be part of the MM community as we learned about farmers’ experiences.

4.5. Other Findings for Further Investigation

Through our research we discovered a few other findings in addition to our results while conducting observations and interviews. We thought the discoveries that arose were intriguing and could be further researched to develop more concrete conclusions.

Health

Cartago is known for having high levels of gastric cancer; this is believed to be tied to excessive agrochemical usage at many farms in the region. During interviews, we asked farmers whether they knew anyone suffering from cancer due to agrochemical usage. Of the eleven MM farmers interviewed, three responded that they knew someone that has suffered from cancer as a result of agrochemicals. However, this data is not completely reliable. It is extremely difficult to determine the root cause of cancer and the farmers may have simply named anyone they knew suffering from any form of cancer. Many farmers believe that switching to MM can better the environment and therefore the health of the people. All of the MM farmers that were interviewed stated that they believed that organic crops are better for the health of the people. Ultimately it could be interesting to perform a case study of the health of people who are exposed to agrochemicals throughout their lives.

Consumer Mentality

Through interviews, we found that many farmers felt as though “consumers do not know or care about the difference between organic and non-organic produce.” They believe that consumers prefer to buy cheap products at the expense of quality. Since this was such a strong opinion among farmers, we decided that a further study into this matter is necessary.

We had the opportunity to smell and taste different crops and really understand the difference between organic and agrochemical produce. We were able to differentiate between agrochemical and organic grown strawberries, while we were not capable before. Agrochemical strawberries have a very strong chemical scent that makes them unappealing, while organic strawberries have a more fresh sweet strawberry smell. Therefore, we think that a next important step would be to conduct a consumer study or a “taste study- prueba del sabor” to see the reaction and understand the consumer knowledge of the benefits of organic techniques.

This study would ask consumers to smell and taste two different types of strawberries, agrochemical and organic, and ask them which one they prefer. If they stated that the organic one is better, MAG would let them know that this grown organically and would then ask if they are willing to pay more to purchase the better quality organic crop. This way people, as consumers, would become more aware of the difference in organic products. MAG would also have data on the beliefs of the consumers and their willingness to economically contribute to the organic market. An example of the proposed evaluation instrument to be used for this consumer study is included in Appendix L: .

Air Quality

Farmers were asked whether or not they have noticed an improvement in the air quality on their farms since switching to MM. This information was based solely on the farmers’ responses and comparisons between the agrochemical and MM farms we visited. Since we could not reference the original air quality on the MM farms, we did not have proper baseline data, and thus could not complete a comparison of before and after. Out of the eleven MM farmers interviewed, eight claimed that they have noticed an improvement in the air. However, this data was only collected verbally and had no scientific data to support it; therefore it would be pertinent to verify farmer’s opinions with a scientific study. This study would encompass the oxygen, carbon dioxide, and nitrogen levels of the air near organic farms and would compare those with levels recorded near agrochemical farms. This way there would be empirical scientific support to the claim that organic agriculture improves the air quality and thus the environment.

5. CONCLUSIONS

To draw conclusions, as stated in Section 3.3, we developed a definition of success for the MM Program. The program is successful if farmers implement MM techniques taught by MAG and reap social and economic benefits while having minimal negative effects on the environment. Based on our findings, we have determined that the trainings and techniques are both effective and have positive social, economic, and environmental impacts. Overall, the program is successful. Specifically, we achieved our research objectives with the following conclusions:

Objective 2: Evaluation of the Techniques

1. **MM techniques improve crop quality and control pests when applied correctly**

Objective 3: Evaluation of the Trainings

2. **The MM trainings are successful, but there is room for improvement**

Objective 4: Evaluation of the Social, Economic, and Environmental Impacts of the MM Program

3. **Soil is healthier when farmers use MM rather than agrochemicals**
4. **MM techniques are cost effective for farmers**
5. **Organic techniques present opportunities for innovation and entrepreneurship**
6. **Farmers experience development in personal and community relationships**

This section summarizes our findings and shows how they lead to recommendations made in Chapter 6. Overall, we have seen that the MM Program sustainably restores balance in agriculture and empowers farmers, giving them tools they can use to better their lives.

5.1. TECHNIQUE CONCLUSIONS

Finding 1: MM Techniques improve crop quality and control pests when applied correctly

Crop quality is better when grown with MM rather than agrochemicals. During farm visits, we visually inspected leaves, roots, and fruit. On most MM farms, the plants had properly colored leaves, extensive roots that housed nitrogen-fixating bacteria, and high quantities of large, colorful fruit. We compared strawberries grown with agrochemicals to those grown with MM. The MM strawberries were larger and more colorful, more flavorful and more fragrant.

MM reduces harm from pests. We analyzed leaves for evidence of whitefly, red spider, coffee rust, and other ailments. Plants at a few farms showed the effects of these plagues, and farmers confirmed these observations during interviews. However, farmers also reported that the MM was managing the plagues. Many farmers continued on to explain that MM worked where agrochemicals had failed. Often,

even when pests were present, leaves were still bright green and free of holes and discoloration. MM maintains balance between plants, plagues, and the plagues' natural predators.

5.2. Trainings Conclusions

Finding 2: The MM Trainings are successful, but there is room for improvement

The three-part training enables farmers to implement techniques correctly. We evaluated the effectiveness of the trainings by assessing whether farmers made MM correctly. We observed the appearance and smell of MM products and the containers in which they were made. Farmers who completed all three trainings applied the techniques correctly. Their MM was made in sealed containers, smelled ripe, and was properly colored for the techniques applied. However, one farmer who had only attended the first session had made MM in open buckets, and there was foul-smelling mold growing on top. This incidence drew our attention to the importance of the three-part process.

Farmers are engaged in the trainings and willingly participate. We observed the second training to evaluate the efficacy of the training. A key observation was that farmers were continuously engaged. They actively participated in making the MM products. Even when not part of the action, they continued to discuss the techniques on the side. The high level of participation and engagement in Ing. Tencio's training indicated that trainees found value in the material.

The technical guide makes it easy to review the material. All trainees are provided with a short technical guide that describes 25 insecticides, fungicides, herbicides, and fertilizers made with MM. The guide describes the materials, procedure, and applications of each technique. Farmers can use the guide as a quick reference to remember techniques.

Farmers are satisfied with the trainings. During interviews, we asked farmers to describe their satisfaction with the trainings. Of the 11 farmers interviewed, all reported positive sentiments. While satisfaction is not a direct indicator of the efficacy of the trainings, there is a correlation between satisfaction and engagement, and between engagement and ability to implement techniques properly.

5.3. Social, Economic, and Environmental Impacts of the MM Program

Finding 3: Soil is healthier when farmers use MM instead of agrochemicals

MM improves the physical composition of soil. We observed that soil treated with MM was usually dark in color, damp to the touch, fragrant, and characterized by visible organic matter like decomposing leaves and sticks. In contrast, soil treated with agrochemicals was dry, odorless or acrid, and powdery. Dust plumed when we walked through fields.

Farmers report that MM improves the chemical composition of soil. While we were not able to analyze chemical soil tests, farmers reported that MM increased the nutrient content of their soil. Farmers

reported that MM decomposed organic material quickly to restore nutrients. Some MM techniques also incorporated additive minerals where soil nutrients are deficient.

MM renews biological balance. Soil on the MM farms contained both microorganisms and macroorganisms. Some farmers had biological soil tests that reported high quantities of beneficial microorganisms. In addition, small plants and wildlife were abundant on farms that use MM. The presence of macroorganisms indicated that there was little contamination on the farm and that ecological balance had been restored.

Finding 4: MM techniques are cost effective for farmers

Only some farmers increase sales and selling prices. During interviews, we asked farmers whether they sold more crops and/or sold for higher prices since using MM. Only four of the eleven interviewees responded positively to both questions, leading to inconclusive results. Findings show that there are discrepancies over whether MM crops sell for higher prices; however, the economic motivation for using MM is that production costs are significantly reduced.

Low production costs make MM economically preferable to agrochemicals. We used data provided by MAG and testimony from MM farmers to compare production costs of various crops throughout the region. While the data was not entirely congruent (data was not equally available for MM and agrochemical crops), general trends showed significantly reduced production costs for MM farmers. Those interviewed reported 50% - 70% expense reductions. Though further research is needed to understand the scope of this finding, we conclude that MM is financially preferable to agrochemicals because production costs are so reduced.

Finding 5: Organic techniques present opportunities for innovation and entrepreneurship

Many farmers adapt MM techniques to increase production and profitability based on the materials available on their farm. During farm visits and interviews, several farmers showed us variations on the MM techniques they had created. Some farmers use ash from kitchen stoves, burned organic material, or nearby volcanoes to augment the mineral composition of the MM. Other farmers have developed new planting techniques, such as growing plants in bags. While these techniques are not taught in MAG's MM Program, they appeared on multiple farms across Cartago where MM is used.

Some farmers use organic techniques in entrepreneurial ways. During interviews and farm visits, we met a number of producers who sell MM and MM products. One farmer sells liquid MM in reused plastic bottles. Other farmers have added MM to an array of other organic techniques to create integrated farms, farms that use organic waste to grow crops and sustain livestock, creating a closed cycle. Many integrated farms also capitalize on agrotourism. We met with a number of farmers who either run or aspire to run integrated farms now that they use MM. We have also seen a number of strong female farmers who have embraced the techniques, indicating a relationship between changing gender roles and the use of organic techniques.

Finding 6: Farmers experience development in personal and community relationships

Farmers reported that the MM Program has further tightened the already close-knit farming community. Farmers who live in close proximity or on parceled farms explain that they come together to make MM. Farmers have developed friendships through the trainings and often rely on each other for advice. Even farmers who were trained at different times in different places have reported calling on each other's advice.

Farmers have also developed ties to the wider community. Some farmers who have more crops than they need give away surplus to neighboring communities and donate it to those in need. We experienced this kindness and outreach at many of the farms we visited as we were welcomed into their communities and treated like family with food and drink—all organic of course.

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6. RECOMMENDATIONS

Based upon these conclusions, we developed six recommendations for the MM Program. In this section, we address findings, farmers' opinions, limitations, and opportunities presented by the study in order to provide the following recommendations for MAG:

Opportunities to improve the Techniques

1. **Incorporate innovations and lessons learned from other farmers into techniques**
2. **Conduct further scientific studies about MM**

Opportunities to augment the Trainings

3. **Revise and expand the training instruction materials**
4. **Increase the number of trainings and follow-up workshops**

Opportunities for Program Expansion

5. **Teach farmers how to train other farmers**
6. **Work with El Ministerio de Educación Pública to develop an organic agriculture program for public schools**

These sections elaborate upon our recommendations to MAG and reflect our ideas to help MAG promote the MM program and extend it throughout Costa Rica.

6.1. OPPORTUNITIES TO IMPROVE MM TECHNIQUES

Based upon our findings, we have formulated some recommendations to improve the efficacy of the MM techniques. These techniques are efficient and successful when applied properly, but user feedback shows room for improvement.

Recommendation 1: Incorporate innovations from farmers into the techniques trained

Our findings showed that farmers have not only embraced MM, but also adapted the techniques over time. Many farmers felt that they needed to make changes to the techniques in order to meet their specific needs. For example, a number of farmers reported using *prueba y error*—trial and error—to perfect the content of their *bokashi* in different applications. One farmer emphasized the importance of trial and error as part of making the new organic techniques viable for different farmers' styles. In another instance, one farmer developed a way to make MM in small containers that can be sold. She recommended that the techniques be taught on a smaller scale because it can be difficult to obtain the large drums they use to cultivate MM.

Farmers' innovations are important to the evolution of the MM techniques and the overall program. Incorporating farmers' breakthroughs into the trainings will disseminate farmers' experiences to new trainees and create an iterative cycle to improve the MM techniques. Ing. Rolando Tencio could include student-generated techniques in his trainings. These ongoing adjustments will keep the techniques up-to-date and efficient, improving long-term program outcomes.

Recommendation 2: Conduct further scientific studies about MM

Currently, there is a lack of scientific research and evidence on the success of MM. This technique is not well-publicized around the world, and there has not been much attention given to scientific analysis of MM. Further, many farmers expressed interest in the microbiology behind MM. We believe that by conducting scientific studies and publishing data on MM, MAG may provide evidence to encourage agrochemical farmers to switch to organic. These studies could include physical, chemical, and biological soil analyses, and formal comparison of crop production between MM and agrochemical crops. If more scientific studies are published showing the benefits of organic farming, the empirical data could increase the chances that more farmers would be willing to implement such techniques.

6.2. OPPORTUNITIES TO IMPROVE THE TRAININGS

We provide the following recommendations to MAG in order to improve the efficiency of the trainings and trainee comprehension. Our hope is that these recommendations will help the MM Program to expand and benefit more farmers throughout Costa Rica.

Recommendation 3: Revise and expand the training instruction materials

Our first recommendation to MAG is to revise and increase the number of the instruction materials given out at trainings. Though the materials provided are sufficient to present the ideas of the MM training, we believe that they can be improved. We recommend a change in design of the PowerPoint presentation shown at the first session. The slides are wordy and, as studies show, can be confusing or overwhelming to the audience (Alley, 2013). We believe slides with fewer words and more visuals will better engage farmers in the lectures and better convey concepts. Beyond revising the PowerPoint, we suggest compiling the extended background information and methods of MM into a comprehensive booklet that farmers can reference at any time. The current guide (Appendix C:), published by MAG, provides a quick reference for farmers, but the information can be elaborated upon. By including the step-by-step instructions to make MM, the background information, and any potential studies to verify claims, farmers can feel more secure about trying these techniques, and might find more value in the trainings.

Recommendation 4: Increase the number of trainings and follow-up workshops

We also recommend increasing the number of trainings and follow-up assessments. Many of the farmers we talked to expressed that having more trainings would be beneficial, so that they can

continue to learn. By increasing the number of trainings, the number of interactions between farmers and trainers would increase throughout the process of learning MM.

In addition, information should be presented over a longer period of time. As mentioned in Chapter 4, it is difficult to become an expert in a subject in a short amount of time. By increasing the training time and number of trainings, MAG can introduce new techniques in later sessions and allow more time to review techniques farmers have already learned.

We believe that MAG can conduct the MM Program trainings in a more iterative and continuous manner. Currently, the trainings happen across three sessions that involve theory, practice, and assessment (see Figure 12). This model is linear and has a definitive end. Following the sessions, farmers are on their own to continue practicing the techniques. Although this model is successful, we propose a new, cyclical model that will provide further trainings for farmers as seen in Figure 13. In this model, theory is still presented first and followed by practice. However, the assessment phase can either generate new ideas that can be spread among farmers, or lead into more practice and assessment sessions. Theory and practice sessions can occur throughout the year, continuously introducing farmers to new twists on the MM techniques. By holding more frequent assessments, MAG can support farmers as they experiment with MM.

Several farmers offered that they would like to have more follow-up assessments after the trainings, or "chats" to share their experiences and expand their knowledge. We recommend that there be a follow-up meeting six months after the training where farmers can gather, share their ideas, successes, and failures, and learn more about the techniques that they are implementing.

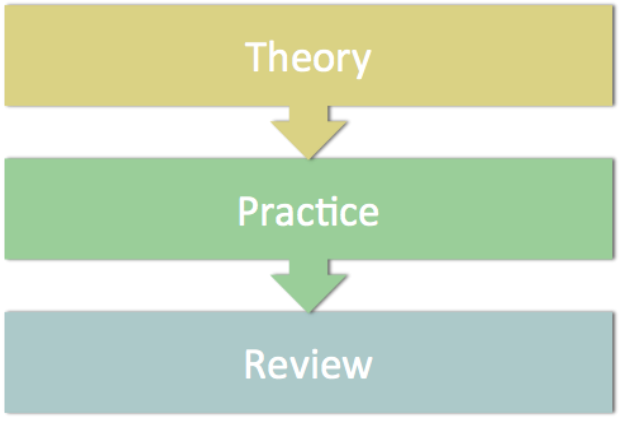

Figure 12. Current Training Model

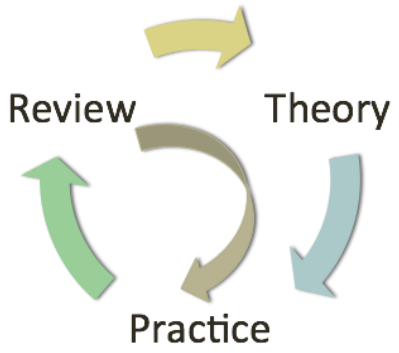

Figure 13. Proposed Training Model

6.3. Opportunities for Program Expansion

Recommendation 5: Teach farmers how to train other farmers

Our next recommendation is to teach farmers MM pedagogy, so that they can become trainers. One farmer, who was trained in 2012, stated that the best way to convince farmers of the results of this technique is to hear it from another farmer. Farmers who are learning this technique might benefit from the experiences and experiments of these farmers-now-trainers. Those who have been implementing and experimenting with MM will be valuable sources of information for new trainees.

Stemming from the previous recommendation of having more trainings, one of the extra sessions could be to train farmers to be trainers, giving them the tools to "pay it forward." Ing. Rolando Tencio could teach farmers how to demonstrate their knowledge of MM to other farmers. This way newly trained farmers, not only learn from an engineer and experienced trainer, but also from a successful farmer with similar goals to their own.

Although Ing. Rolando Tencio is currently performing the trainings efficiently, he is but one person at MAG who travels across the Eastern Central Region to train farmers. If more farmers were able to teach each other these techniques, the MM program could grow beyond the scope of the Eastern Central Region of Costa Rica.

Recommendation 6: Work with El Ministerio de Educación Pública to develop an organic agriculture program for public schools

A theme that emerged repeatedly throughout the interviews and focus groups is the importance of youth education to promote sustainable farming for the next generation. One of the MAG extension agents we spoke with pointed out that there are programs in schools to promote recycling and conservation of water sources—why not a program to teach children about organic farming and MM?

Based on farmers' suggestions, we recommend that MAG work with El Ministerio de Educación Pública to develop an educational program for public schools that teaches children about organic agriculture in relation to the country's larger movement toward sustainability. This program could teach the theory and importance of organic farming and give children the opportunity to experiment with MM and other organic techniques firsthand. Students could create MM and use the bioinsumos to grow their own garden, learning to grow food and take care of the earth. MAG can provide contacts for nearby farms where students can have further learning experiences. Engaging youth in agriculture raises awareness of the issues with agrochemical use to benefit future generations in Costa Rica.

7. CONCLUDING REMARKS: PROSPECTS FOR MOUNTAIN MICROORGANISMS IN THE LIVES OF FARMERS

We hope that MAG will be able to implement these recommendations in the MM Program over the coming years. Throughout this study, we have learned a lot about the potential MM has to impact the lives of farmers, to make organic agriculture financially viable on a large scale, and to maintain balance in the environment. Through our evaluation of the MM program, we predict that financial stability and environmental health, achieved in part through the use of MM, will provide a sustainable platform from which farmers, and those who benefit from their produce, will achieve better quality of life.

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APPENDIX A: RESUMEN EJECUTIVO

An extended Executive Summary was translated into Spanish and presented to El Ministerio de Agricultura y Ganaderia. It was not only disseminated throughout the regional office in Cartago, but also delivered to the desk of the Minister of Agriculture.

UNA EVALUACIÓN SOCIAL, ECONÓMICA Y AMBIENTAL DEL PROGRAMA DE MICROORGANISMOS DE LA MONTAÑA (MM) EN LA REGIÓN CENTRAL ORIENTAL DE COSTA RICA.

Entregada por:

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RESUMEN EJECUTIVO

ANTECEDENTES

"Panza llena, corazón contento", es un dicho muy común para señalar la satisfacción que acompañe un buen rato con amigos. Mientras la comida es importante en todas culturas y sociedades, los costarricenses, más coloquialmente conocidos como "Ticos", usan esta frase para indicar que la comida alimenta y, a la vez, une a la gente alrededor de la mesa; de ahí surge, incluso, la palabra bien hispana de *sobremesa*, o sea, la conversación que sucede por horas después de comer. No existe una palabra igual en inglés. En Costa Rica, un país de Centroamérica que busca promover sostenibilidad, la comida conecta la sociedad, la economía y el medioambiente por medio de la agricultura. Cuando sea sostenible, agricultura pone en equilibrio a la gente, la prosperidad y el planeta para así llevar al mejoramiento de vida

La agricultura sostenible tiene dimensiones ambientales, económicas y sociales. El crecimiento de cultivos depende de la salud de la tierra. Productores dependen de la cosecha de cultivos para poder mantener estabilidad económica. El equilibrio existe entre las necesidades de los productores y el medioambiente. Cuando alguna parte está desequilibrada, hay problemas para los productores.

A veces, el equilibrio de agricultura está interrumpido por cambios de estación y clima. Cada época trae plagas diferentes que hacen daño a las plantas y amenazan a la producción de cultivos y el sustento de productores.

Para mitigar estas amenazas, los productores recurren a agroquímicos. Sin embargo, tal como bacteria desarrolla una resistencia a los antibióticos, las plagas se hacen resistivas a los agroquímicos con tiempo. De ahí los agroquímicos deben usase con más frecuencia para luchar contra las plagas. Hace 30 años, Costa Rica era uno de los países que más importaba agroquímicos de todo el mundo (Universidad de Costa Rica, 2010).

Aunque muchos productores dependen de agroquímicos, tienen una miríada de consecuencias desfavorables en lo social, lo económico y lo ambiental. Algunas investigaciones han mostrado que agroquímicos tienen impactos adversos para el medioambiente ya que afectan a la calidad de cultivos y suelo e inclusive filtran desde el suelo a los nacimientos de agua y comida (Gliessman, 1998). Cuando las química se filtran a los suministros de comida y agua, amenazan la salud de la gente. En la Región Central Oriental de Costa Rica, el cáncer gástrica es destacado y ha sido conectado al uso de agroquímicos (Veerman, 2001). Además, los agroquímicos son caros, y productores gastan más de $5,000 (~₡3,000,000) para producir cultivos cada año (Tencio, 2014).

En años recientes, ha habido un movimiento global de remplazar agroquímicos con técnicas sostenibles. El Ministerio de Agricultura y Ganadería (MAG) en la Región Central Oriental de Costa Rica empezó a enseñar técnicas orgánicas a productores en 2012 cuando el Ing. Rolando Tencio, un ingeniero agronómico para MAG, inició un programa para capacitar la técnica orgánica de Microorganismos de la Montaña (MM) a productores a través de la Región Central Oriental.

MM es una técnica que usa bacteria y hongos de la tierra del bosque para hacer bioinsumos como biopesticidas y biofertilizantes. Productores cosechan materia orgánica desde el bosque o montaña y la combinan con agua, maleza y cáscaras de arroz. Se pone la mezcla en un recipiente sellado y se deja para fermentar por 15 días. Productores usan la mezcla —se llama MM sólido— para hacer varios tipos de biopesticidas y biofertilizantes (Tencio, 2015). MM es muy versátil y accesible, por lo cual permite a productores tomar en sus propias manos su estabilidad económica mientras hacen una diferencia en la salud del ambiente y de la gente.

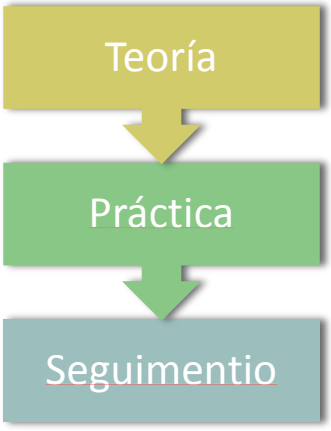


Figura 1: El modelo actual del Programa de MM

Actualmente, MAG enseña las técnicas de MM en un programa de capacitaciones de tres pasos conducido por el Ing. Tencio. Las capacitaciones incluyen sesiones de teoría, práctica y seguimiento (Figura 1). Durante la primera sesión con productores, el Ing. Tencio introduce la teoría de MM por una presentación de PowerPoint, una serie de folletos y una guía. La segunda sesión es una práctica con una demostración y participación en la cual los productores tienen la oportunidad de preparar MM por mano. En la tercera sesión, el Ing. Tencio viaja a cada finca y asesora la implementación de las técnicas al ver la calidad de los productos de MM y los cultivos. Desde este asesoramiento, proporciona sugerencias y recomendaciones a los productores para mejorar el uso de MM y así mejorar los resultados.

Sigue con los productores hasta que puedan usar las técnicas correctamente.

Desde la primera capacitación en 2012, Ing. Tencio ha aumentado el programa de MM para alcanzar a más de 200 productores en la Región Central Oriental. El programa empezó con un grupo pequeño en el diciembre de 2012, cuando solamente había sesiones de teoría de 14 personas. Desde aquel tiempo, desarrolló el proceso de tres pasos. El año pasado, Ing. Tencio capacitó a más de 100 productores. Entre enero y abril de 2015, capacitó a 66 productores y hay planes para más. El programa de MM crece por palabra de boca entre productores que participan; pero hasta este momento, las técnicas, las capacitaciones y los impactos del programa de MM no han sido evaluados.

METODOLOGÍA

El propósito del este estudio fue evaluar el Programa de MM como una unidad entera. Para lograr esta meta cumplimos los objetivos a continuación:

Objetivo 1: Estudiar los conceptos de la agricultura, y estudiar las técnicas y las capacitaciones en Costa Rica

Objetivo 2: Evaluar la eficacia de las técnicas de MM

Objetivo 3: Evaluar la eficacia de las capacitaciones de MM

Objetivo 4: Evaluar los impactos sociales, económicos y ambientales del Programa de MM

Para completar estos objetivos, utilizamos informes económicos de MAG y hicimos entrevistas individuales, grupales y observaciones de las visitas en las fincas para recoger datos cualitativos. Creamos instrumentos para recoger esta información y planeamos las visitas en las fincas dependiendo de la disponibilidad de los productores. Ing. Tencio asistió a nuestra investigación porque era el coordinador de las visitas en las fincas, el intermediario entre nosotras y los productores, un recurso informativo, y un guía de la agricultura. Aunque su presencia durante las interacciones de los agricultores puede haber producido un sesgo en sus respuestas, al final el estudio se benefició de su conocimiento, experiencia y relaciones con los agricultores.

Realizamos dieciséis entrevistas: cinco con productores que usan agroquímicos y once con productores que usan MM. El objetivo de estas entrevistas fue recolectar y entender las opiniones de las técnicas agriculturas, los puntos de vista sobre las capacitaciones de MM y la información sobre los impactos sociales, económicos y ambientales del Programa de MM.

En esta línea, realizamos cinco entrevistas del grupo de cinco a diez productores para recoger información similar y también obtener opiniones y recomendaciones para mejorar el Programa. Observamos la discusión para determinar las interacciones sociales y recoger las opiniones de los productores sobre los impactos de los agroquímicos y los MM en la agricultura.

Durante las visitas en las fincas, observamos las condiciones ambientales de la finca. Después de nuestras primeras visitas en las fincas, desarrollamos un instrumento de observación para notar indicadores, como la calidad de los cultivos, la incidencia de las plagas y las condiciones del suelo en cada finca. Documentamos observaciones por grabaciones de video y fotografías para analizarlas después.

De la información recogida, logramos sacar conclusiones por análisis del contenido de las respuestas, las opiniones y las historias de los productores. También, consultamos datos económicos de MAG para comparar los costos de producción con MM contra los costos promedios regionales con agroquímicos. Nuestros resultados nos permitieron evaluar la eficacia de las técnicas y las capacitaciones y también evaluar los impactos del Programa de MM. A partir de nuestros resultados, desarrollamos recomendaciones para MAG para mejorar y expandir el Programa de MM.

CONCLUSIONES

Analizamos los datos de las entrevistas individuales, las entrevistas grupales y las observaciones para evaluar la eficacia de las capacitaciones de MM, la eficacia de las técnicas de MM y los impactos sociales, económicos y ambientales del Programa de MM de MAG. Para llegar a nuestras conclusiones, desarrollamos una definición de "un programa exitoso". Definimos un programa exitoso como uno en el cual productores puedan implementar las técnicas de MM como fueron ensañadas por MAG y así conseguir beneficios sociales y económicos sin perjudicar el medioambiente. Nuestros resultados reflejan los éxitos del Programa de MM y también las oportunidades para el desarrollo.

Objetivo 2: La evaluación de la eficacia de las técnicas de MM

- *Las técnicas de MM mejoran la calidad de los cultivos y reducen la incidencia de las plagas y las enfermedades cuando se hagan correctamente*

Objetivo 3: La evaluación de la eficacia de las capacitaciones de MM

- *Las capacitaciones de MM son exitosas, pero hay posibilidades para mejorarlas*

Objetivo 4: La evaluación de los impactos sociales, económicos y ambientales del Programa de MM

- *El suelo es más sano cuando los productores emplean los MM en vez de los agroquímicos*
- *Las técnicas de MM son rentables para los productores*
- *Las técnicas orgánicas llevan a muchas oportunidades innovadoras y empresariales*
- *Los productores desarrollan relaciones personales y dentro de la comunidad a través de las capacitaciones*

Basándose en nuestros resultados, logramos llegar a esta conclusión: el Programa de MM es efectivo y tiene impactos positivos. Además, al caracterizar los cambios sociales, económicos y ambientales conectados, identificamos temas como la calidad de los cultivos, la salud y la mentalidad de los consumidores. Estos temas representan la superposición de los impactos sociales, económicos y

ambientales. Concluimos, en fin, que un programa exitoso y el mejoramiento de vida tienen sus raíces en el concepto del equilibro entre el medioambiente, la economía y la sociedad.

Conclusión 1: MM mejora la calidad de los cultivos y reduce la incidencia de las plagas cuando se haga correctamente

La calidad de los cultivos es mejor cuando se cultivan con MM en vez de los agroquímicos. Durante las visitas a las fincas, inspeccionamos las hojas, las raíces y las frutas de los cultivos. En las fincas de MM, las plantas tenían colores adecuados y vibrantes en las hojas, tenían raíces extensivas con las bacterias que fijan el nitrógeno y tenían una gran cantidad de frutas grandes. Comparamos las fresas que se cultivan con técnicas de MM con las fresas que se cultivan con agroquímicos en la Región Central Oriental. Las fresas de MM eran más grandes y tenían más color, sabor y olor.

Figura 2: Un comparación de las fresas se cultivan con agroquímicos (izquierda) y con técnicas orgánicas (derecha).

MM reduce el daño de las plagas. Analizamos las hojas para evidencia de mosca blanca, araña roja, la roya de café y otras enfermedades. Las plantas en algunas fincas de MM mostraron los efectos de estas plagas. Los productores confirmaron nuestras observaciones durante las entrevistas. Sin embargo, los productores reportaron que las técnicas de MM ayudan a manejar las plagas y las enfermedades. Muchos productores dijeron que las técnicas de MM funcionaron cuando las técnicas de agroquímicos faltaron. Muchas veces las hojas de las plantas todavía eran verdes brillantes y no tenían los hoyos que señalan la presencia de las plagas. MM establece y mantiene el equilibrio entre las plantas, las plagas y los depredadores de las plagas.

Conclusión 2: Las capacitaciones de MM son exitosas, pero hay posibilidades para mejorarlas.

Las 3 partes del modelo de capacitación funcionan para enseñar las técnicas de MM y para que los productores implementen las técnicas correctamente. Evaluamos la eficacia del tercer paso de las capacitaciones, el seguimiento, al ver los productos de MM hechos por los productores. Observamos la apariencia y el olor de sus productos y también los recipientes de MM. Los productores que habían completado las tres partes de las capacitaciones implementaron las técnicas correctamente. Sus productos de MM se hacían en un recipiente hermético, se olían como productos fermentados y tenían el color correcto para cada técnica. Sin embargo, un productor que había asistido solo una capacitación de teoría tenía MM poco adecuado ya que el recipiente estaba abierto, el MM olía mal y había hongos encima del producto. La situación de este productor nos ilustró la importancia de las tres partes de las capacitaciones.

La Guía Técnica es fácil para repasar y estudiar la materia. Todos los participantes de las capacitaciones reciben una guía técnica y corta que describe los veinticinco tipos de insecticidas, fungicidas, herbicidas y fertilizantes que surgen de MM. La guía describe los materiales, los métodos y las aplicaciones de cada técnica. Los productores pueden usar la guía para consultar y recordar las técnicas.

Los productores están satisfechos con las capacitaciones. Durante las entrevistas, les pedimos a los productores que describieran sus opiniones y sentimientos sobre las capacitaciones. Todos los productores que entrevistamos tenían sentimientos positivos sobre las capacitaciones. Mientras que la satisfacción no sea un indicador directo para la eficacia de las capacitaciones, hay una correlación entre la satisfacción y el compromiso y también entre el compromiso y la capacidad de implementar las técnicas correctamente.

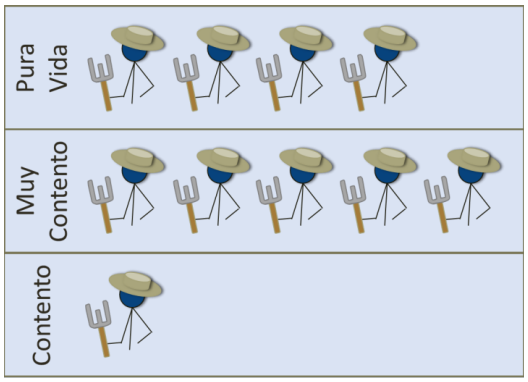


Figura 3: La satisfacción de los productores sobre las capacitaciones

Conclusión 3: El suelo es más sano cuando los productores usan MM en vez de los agroquímicos

MM mejora la composición física del suelo. Observamos que el suelo con MM tenía un color oscuro, una sensación húmeda, un sabor prominente y características como la materia de descomposición de las hojas y ramas. Al contrario, el suelo con agroquímicos era seco, no tenía sabor o era acre, y tenía mucho polvo. Durante las visitas a las fincas con los agroquímicos, el polvo se levantó sobre nuestros pies.

Los productores mantienen que MM mejora la composición química del suelo. Mientras que no podríamos estudiar los análisis del suelo, los productores nos informaron que MM mejora los nutrientes en el suelo. Muchos productores sostenían que MM contribuye a la descomposición rápida de la materia orgánica. Algunas técnicas incorporan minerales cuando los nutrientes no existan.

MM restablece el equilibrio biológico. El suelo de las fincas de MM contenía microorganismos y macroorganismos. Algunos productores usan los análisis biológicos del suelo y nos informaron que había mucho de los microorganismos. También, la flora y fauna era abundante en las fincas que usan MM. La presencia de los microorganismos indica que había menos contaminación y el equilibro fue restablecido.

Conclusión 4: Las técnicas de MM son rentables para los productores.

Solamente algunos agricultores aumentan las ventas de sus cultivos y los precios de venta. Durante las entrevistas, les preguntamos a los productores si venden más cultivos y si los venden por un precio más alto que antes de usar MM. Solamente cuatro de once (4/11) contestaron positivamente a ambas preguntas; los datos eran insuficientes para sacar conclusiones. Los resultados muestran que hay discrepancias sobre si los cultivos con MM venden por precios más altos. Sin embargo, la motivación económica para el uso de MM es que los costos de producción se reducen considerablemente.

Bajos costos de producción hacen que MM sea económicamente preferible a los agroquímicos. Usamos datos por MAG y los testimonios de los productores para comparar los costos de producción de cultivos variables en la Región Central Oriental. Mientras que los datos no eran congruentes, la tendencia general era que hay costos de producción más bajos en los MM que en los agroquímicos. Los entrevistados dijeron que hay una reducción de 50-70% en los costos. Hemos examinado específicamente los costos de producción de fresas en la Región Central Oriental. Dos agricultores de agroquímicos reportaron costos anuales llegando a 250,000 CRC para crecer sus fresas. Una usuaria de MM en la misma región reportó costos de producción de solamente 87, 000 CRC anualmente. Aunque se necesitan más investigaciones para comprender el alcance de este hallazgo, concluimos que los MM son más económicamente preferibles que los agroquímicos porque los costos de producción son tan reducidos.

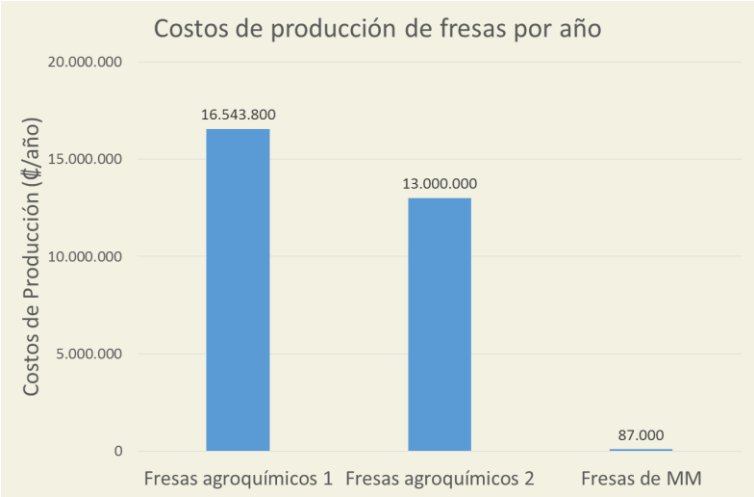


Figura 4: Una comparación entre los costos de producción en fincas de fresas en la Región Central Oriental

CONCLUSIÓN 5: LAS TÉCNICAS ORGÁNICAS CONDUCEN A OPORTUNIDADES INNOVADORAS Y EMPRESARIALES.

Muchos productores usan las técnicas de MM para aumentar su producción de los cultivos y la rentabilidad basado en los materiales que existen en sus fincas. Durante las visitas a las fincas y las entrevistas, varios agricultores nos mostraron variaciones en las técnicas de MM que habían creado. Algunos productores utilizan ceniza de estufas de cocina, material orgánico quemado, o ceniza de los volcanes para aumentar la composición mineral de los MM. Algunos productores han desarrollado técnicas nuevas de plantación, por ejemplo crecer los cultivos en bolsas que pueden vender. Aunque estas técnicas no se enseñen en el Programa de MM del MAG, aparecieron en varias comunidades a través de Cartago donde la gente utiliza MM.

Algunos productores usan las técnicas orgánicas en maneras empresariales. Durante las entrevistas y visitas de las fincas, conocimos muchos productores que venden los productos de MM. Uno de los productores vende el MM líquido en botellas plásticas. Otros productores utilizan MM en otras técnicas orgánicas para hacer las fincas integrales, o fincas que usan la basura orgánica para cultivar los cultivos y ganadería en un ciclo. Muchas fincas integrales capitalizan en el turismo de agricultura. Conocimos un gran número de productores que tienen o quieren tener una finca integral porque ellos usan MM. También, observamos que hay muchísimas agricultoras que usan las técnicas orgánicas de MM. Es posible que haya una correlación entre los cambios en las posiciones de las mujeres y el uso de técnicas orgánicas.

CONCLUSIÓN 6: LOS PRODUCTORES DESARROLLAN RELACIONES PERSONALES Y DENTRO DE LA COMUNIDAD CON LAS CAPACITACIONES

Los productores de MM que viven en los parceles o en proximidad de otros productores nos informen que se reúnen para hacer las técnicas de MM juntos. Los productores han desarrollado amistades durante las capacitaciones y confían el uno en el otro para dar sugerencias en torno a mejorar las técnicas de MM. También, los productores que no se capacitaron juntos nos informaron que ellos confían en los consejos de otros productores.

Los productores que usan MM desarrollan lazos con la comunidad entera.

Algunos productores que tienen demasiados cultivos donan sus cultivos a la comunidad y a las caridades. Observamos y nos sentíamos la amabilidad y la hospitalidad en nuestras visitas a todas las fincas. Fuimos recibidos con todo el corazón en todas las fincas, en incluso logramos probar todas las comidas orgánicas. ¡Las comidas orgánicas eran muy ricas!

RECOMENDACIONES

A partir de estos resultados, concluimos que el Programa de MM es efectivo en su estado actual. Identificamos oportunidades que MAG puede usar para aumentar las capacitaciones, mejorar las técnicas y expandir el Programa. Las siguientes recomendaciones se derivan de las sugerencias de los productores y nuestros resultados.

Hay oportunidades para mejorar las técnicas

Incorporar las innovaciones de los productores a las técnicas capacitadas. Desde el inicio del programa, los productores se han ido adaptando las técnicas para conformar a las necesidades particulares de sus fincas. Dado que muchas fincas en la región tienen necesidades diferentes, recomendamos que MAG incorpore las innovaciones a las capacitaciones, por lo que los productores podrían propagar sus conocimientos a otros con ideas o problemas similares.

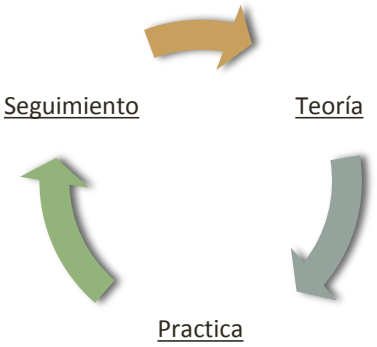
Disponer más estudios científicos sobre los MM. Muchos productores solicitaron más información sobre la microbiología y la eficacia de los MM. Recomendamos que MAG patrocine estudios para determinar cuáles bacterias, hongos y microorganismos funcionan lo mejor, así como estudios de casos de la evolución de la calidad del suelo en las fincas antes y después de los MM. El uso de pruebas uniformes del suelo ayudará con estos dos estudios.

Hay oportunidades para mejorar y aumentar las capacitaciones

Revisar y expandir los materiales de instrucción de las capacitaciones. Los materiales de instrucción actuales pueden compilarse en un folleto detallado con información adicional, como "recetas" para la toma de MM y formación científica empírica. Con esta información, MAG producirá un manual

acumulativo que abarca toda la teoría necesaria para practicar técnicas de MM. Materiales adicionales reforzarán el PowerPoint presentado durante las capacitaciones, lo que permite a los agricultores a continuar el aprendizaje en sus casas.

Aumentar el número de las capacitaciones e implementar más sesiones en el proceso de instrucción para mejorarlo. Muchos productores informaron que habría beneficios si hubiera más sesiones de la práctica y del seguimiento. Tan poco como una sesión de capacitación adicional podría conducir a un mayor número de agricultores que implementan MM con confianza y experiencia suficiente. Nuestro modelo propuesto, que se basa en el modelo actual, sugiere una continuación del modelo de tres partes



en un ciclo, por lo que los agricultores están aprendiendo constantemente (Figura 5).

Figura 5: El modelo nuevo de las capacitaciones del Programa de MM

Hay oportunidades para expandir el alcance del Programa de MM.

Enseñar a los productores para ser técnicos y capacitadores. Actualmente, hay una persona que facilita las capacitaciones de MM, Ing. Tencio. Si el programa se expande, habrá una necesidad de una fuerza más grande de capacitadores. Para lograr este objetivo sin agregar más personas al programa, recomendamos que MAG instituya un taller para enseñar a los productores para enseñar otros productores de las técnicas orgánicas. Muchos productores pueden estar más dispuestos a probar MM si otro productor que ha tenido éxito con las técnicas orgánicas les muestra los beneficios.

Trabajar con el Ministerio de Educación Pública para desarrollar un programa de la agricultura orgánica para el público. Recomendamos que MAG empiece un programa pedagógico para enseñarles a los niños sobre las técnicas orgánicas porque así la idea de la agricultura sostenible puede sembrarse. Si les educamos a los jóvenes de Costa Rica, es posible que podamos ayudar a generaciones futuras. Mediante la introducción de la agricultura orgánica a los niños a una edad temprana, las generaciones

del futuro de Costa Rica pueden tener más conciencia de proteger el equilibrio entre las personas, la economía y el medio ambiente.

RESUMEN

El Programa de MM del Ministerio de Agricultura y Ganadería les ayuda a productores para restaurar el equilibrio natural de su tierra amada desde la cual sacan sus sustentos y sus ganancias. En este estudio, evaluamos la eficacia de las técnicas y capacitaciones, y exploramos los impactos sociales, económicos y ambientales del Programa de MM en total. Concluimos que el Programa es exitoso, que los productores lo perciben valioso y que MM puede producir cultivos sanos para sostener a la gente de Costa Rica. Nuestras recomendaciones para MAG presentan oportunidades para expandir y mejorar el Programa. A través del Programa de MM, MAG puede promover la agricultura sostenible y mejorar la vida de productores por todo el país.

APPENDIX B: EXAMPLE SLIDE FROM MM TRAINING SESSION

The following is a slide taken from Ing. Tencio's training materials. In Section 6.2, we recommend ways Ing. Tencio can improve the training materials.

APPENDIX C: TECHNICAL GUIDE BY ING. ROLANDO TENCIO

This Appendix contains the pages of the Technical Guide that Ing. Rolando Tencio distributes to participants of the MM Program. It explains materials, preparation, and application of 25 MM techniques. Recommendations to expand the Guide are explained in Section 6.2

MAG

Ministerio de Agricultura y Ganadería.
Región Central Oriental
Área de Producción Sostenible

"Guía de elaboración y aplicación de bioinsumos para una producción agrícola mas autosostenible"

Elaborado por: Ing. Rolando Tencio C.

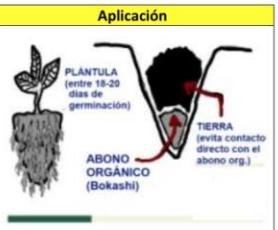
Noviembre 2014

Introducción

Con la finalidad de ofrecer una herramienta útil a los pequeños productores, se confeccionó la guía de "elaboración y aplicación de insumos orgánicos para una producción agrícola más sostenible". El objetivo es que los pequeños productores puedan elaborar sus propios insumos orgánicos o naturales con materiales que se encuentren en las fincas o lugares cercanos, y así reducir costos de producción, evitar en lo posible el uso de agroquímicos, y por ende reducir contaminación de nacientes, ríos, lagos, disminuir afectación a productores, y consumidores a través de alimentos más sanos . Al final poder producir de una forma más autosostenible.

Elaboración de MM (Microorganismos de Montaña), bokashi, biofermentos, biopesticidas , caldos minerales, y fuentes de nutrientes orgánicos.

Insumo a preparar	Materiales	Preparación	Aplicación
1. Elaboración **MM sólido** (estañón 200 lt) 	✓ 1 galón de melaza o azúcar (1 balde) mas 1 gal agua . ✓ 40 kg semolina de arroz (1 saco) (o concentrado animal, o caña de azucar picado) ✓ 60kg de tierra de montaña (1.5 saco) ✓ 1 estañón plástico 200 lt con tapa hermética	Colocar una capa de 10 cm tierra de montaña + 1 saco de semolina + Melaza (regadera), luego mezclar materiales. Agregar agua hasta que quede con un 40% humedad (prueba del puño). Introducir poco a poco la mezcla en estañón y pisonearlo con alguna persona para sacar aire. Una vez lleno, y finalizado el pisoteo, tapar herméticamente. Guardar a la sombra por unos 22 a 30 días (**según zona**). (Si se puede agregar **10 kgs MM solido viejo** para acelerar proceso.)	Este MM sólido lo vamos a ocupar para hacer MM Líquido. Este MM sólido se puede almacenar por 1 o 2 años. Se puede estar sacando el porciones de 8-10 kg MM solido para elaborar 200 lt de MM liquido.
2. Elaboración de 200 lt **MM líquido** 	✓ 8-10 kg de MM solido ✓ 1 gal melaza o 5 kg azúcar en agua. ✓ 200 lt de Agua sin cloro (De rio, manantial o de lluvia) ✓ Estañón plástico de 200 lt. ✓ 1 saco limpio o malla.	Se agrega 8 kg de MM solido al saco, se amarra, se introduce saco en estañón con 200 lt de agua mezclado de previo con un galón de melaza. Tapar con una tela para que no entren insectos. Guardar bajo sombra por unos 15 días. A los 4 días se forman hongos, a los 8 días se forman bacterias y a los 15 días se forman levaduras. Después de 15 días se puede aplicar al campo. Una vez que se activado el MM líquido se puede pasar saco con MM solido a otro estañón con melaza y agua para activar otros 200 lt de MM liquido.	En hortalizas, Se puede aplicar semanalmente al suelo y vía foliar, 1 litro / bomba de 18 lt. Controla enfermedades y plagas, acelera crecimiento de planta,y frutos . Se puede aplicar 100% puro para controlar mildiu. (1 o 2 aplic/sem). Se puede aplicar al alimento animal para mejorar digestión. Remojar semillas con MM para acelerar germinación. Elimina malos olores en porquerizas, gallineros, establos, y descompone materia orgánica más rápido.
3. Abono tipo bokashi (aprox. 28 qq)	✓ 10 sacos de gallinaza o cerdaza, o boñiga, etc. (Nitrógeno) ✓ 6 sacos bagazo de caña o cascarilla de arroz. (fibra) ✓ 40 lt MM liquido activado o 10 kg MM	Cascarilla de arroz primero mas ceniza mas arena mas gallinaza mas melaza mas otros elementos, se mezclan bien.. Es mejor en piso de suelo, para mejor filtración. Humedecer hasta hacer prueba del puño,	Abono rico en microorganismos y nutrientes. En hortalizas se aplica 1 a 3 puños por planta. (De 2 a 3 tm por ha). En café por ej. se aplica 30 sacos de 46kg/ha.

Insumo a preparar	Materiales	Preparación	Aplicación
	solido. ✓ 6 sacos ceniza o carbón. ✓ 20 lt melaza o miel o azúcar (Energía) ✓ 2 sacos arena de tajo o río (minerales) ✓ 2 sacos bokashi viejo (**Si hay disponible).** (potenciador) o 2 sacos base Biofermento. ✓ 1 saco de semolina de arroz o alimento animal. Fuente: Henry Guerrero, APODAR.	que se haga un terrón en la mano. Cada 2 días mezclar, viendo Temperatura que No pase de 50 oC. En dos días bajar altura de 1.20m a 40 cm, luego bajar a 20 cm para mejor aireación. Color debe ser homogéneo. En Cada mezcla se pone MM líquido, o sea cada 2 días. En 20 días está listo. Cuando abono esta frío almacenar en sacos limpios por lo menos un mes.	
4. **Preparación bokashi como sustrato de almácigo. (aprox. 14 qq)** 	✓ 4 sacos de fibra coco (material inerte, mantiene humedad) ✓ 2 sacos cascarilla o granza de arroz. (fibra) o bagazo de caña ✓ 40 lts MM liquido (2 baldes) ✓ 1 saco de semolina de arroz (proteína) ✓ **2 sacos bocashi** (potenciador) ✓ 20 lt melaza (1 balde) (energía) ✓ 4 sacos de tierra roja (textura , porosidad, minerales, inerte, volumen) ✓ 1 saco de carbón o cenizas de caña. ✓ Fuente: JJ Paniagua, APODAR, Zarcero.	Granza primero mas ceniza mas semolina mas fibra de coco mas tierra y carbón, se mezcla todo con MM liquido, melaza y agua. Dejar destapado, es mejor en suelo, Temperatura menor a 65 Grados. Realizar volteo c/4 días, se deja tubo en el centro para que entre aire (Aeróbico). A los 22 días se puede usar. Sustrato es para llenar hoyos de la bandeja. Hacer otro tipo de mezcla pero sin bokashi para tapar hoyos. (cantidad para 180 bandejas de 200 semillas).	Excelente sustrato para almácigos. Usarlo a los 22 días de elaborado. Este se usa para rellenar hoyos. Se elabora otro sustrato similar sin bokashi para tapar la semilla.
5. **Pasto fermentado** (sustituto de boñiga fesca para elaborar biol o fertilizante liquido)	✓ 15 kg de pasto tierno ✓ 40 kg se semolina de arroz. ✓ 1 gal de melaza. ✓ 1 gal de MM liquido (o 2kg MM solido) ✓ 2 bolsas plásticas grandes y dos sacos , o un barril con tapa hermético.	Se corta pasto tierno (gramíneas y leguminosas), picarlo bien, mezclar con semolina, agregar melaza y se guarda en saco y bolsa plástica gruesa o estañón bien tapado, bien compactado, sin aire. Este se fermenta a los 30 días.	El pasto fermentado se usa para elaboración de fertilizante líquido o biol. Es materia orgánica en forma líquida, por lo que llega muy rápido al sistema de la planta, mejorando su desarrollo. Se puede enriquecer con minerales que el suelo y la planta

Insumo a preparar	Materiales	Preparación	Aplicación
			necesite.
6. **Base biofermento 1: Henry Guerrero** (estañón 200 lt) 	**Base biofermento 1:** ✓ 10 kg boñiga fresca orgánica o pasto fermentado (ver ítem 5) ✓ 1gal de suero o leche (lactobacillus) ✓ 1 gal melaza ✓ 20 lt MM liquido ✓ Estañón 200 lt (manguera y botella)	Se dejan 4 días la base (tapado con manguera y botella con agua) sin aire. Así Se reproducen los MM, luego se mezcla con minerales que se vayan a ocupar. Por ej se puede agregar: **4kg sulfato de Potasio** (o harina pescado, huesos), mas 6kg arena o roca molida (Mg, Zn, Boro, Fosforo) o roca fosfórica, mas 8 kg cenizas, mas MM liquido, y agua. En 15 días listo para usar.	**Usar como fertilizante foliar:** **Dosis hortalizas**: 300 cc/bomba 18lt. . **Frutales:** 20 lt/estañón de 200lt. Recomendación: Agregar minerales a la base de biofermento 1, según análisis de suelos. **Biol de Magnesio**: se hace igual , solo se agrega 15 kg de sulfato de Magnesio en lugar de Sulfato de Potasio.
7. Biofermento de fósforo (fuente: Jorge Garro , INTA) (estañón 60 lt) 	• Estañón de 60 L agua • 6 kg sábila • 10 L de leche (suero) • 20 L pasto fermentado (1 balde) • 1 gal de melaza • 20 L de MM liquido activado • 15kg roca fosfórica • 8kg flor de azufre • 42 L de agua sin cloro	Mezclar ingredientes en el estañón, tapar herméticamente, poner manguera y botella con agua, para que salgan gases. En 15 días listo para usar.	Fertilizante liquido y tiene propiedades de fungicida. En hortalizas: aplicar 300 cc/bomba de 18L. cada 10 días. **Frutales:** 20 lt/estañón de 200lt **En papa aplicar 3 veces por semana, 1 lt/bomba al follaje, y 10 lt/bomba al suelo. (Ing. Garro, INTA).**
8. Biofermento o Biol para engruese.	**Base biofermento 1** mas sulfato que se necesite según **análisis de suelo**: ✓ 5lt fosforo ✓ 4 lt potasio ✓ 4 lt Boro ✓ 3 lt Magnesio	Se dejan 4 días la base 1 (tapado con manguera y botella con agua) sin aire. luego se mezcla con los minerales : fosforo, potasio, boro, magnesio, y silicio., y se deja fermentando 15 días más.	**Usar como fertilizante foliar para engruese:** **Dosis hortalizas**: 300 cc/bomba 18lt. **Frutales**: 20 lt/estañón de 200lt

Insumo a preparar	Materiales	Preparación	Aplicación
	✓ 3 lt Silicio		
9. Biol de rocas (60 lt) 	✓ 5 kg rocas molidas o arena rio o tajo. ✓ 20 lt de MM liquido ✓ 1 lt melaza ✓ 20 lt suero de leche ✓ 20 lt de agua	En un barril de 60 lt, agregar 20 lt de agua. Moler piedras, mezclar todos los ingredientes, y se deja en barril bien cerrado por 15 días.	Se aplica 300 cc a 500 cc por bomba. Esto agrega gran cantidad de minerales, que el suelo y las plantas necesitan.
10. **Biopesticida M5** (Insecticida – nematicida-fungicida) (estañón 200 lt). 	✓ 2kg ajos (fermentados es mejor) ✓ 2kg chile picante picadas o licuado ✓ 2 kg cebolla morada picadas o licuado ✓ 2kg jengibre picado o licuado ✓ más plantas aromáticas al gusto (albahaca, ruda, hierbabuena, laurel, orégano, romero, menta, llantén, apazote,neem). ✓ 1gal melaza más agua ✓ 1 gal vinagre, guineo u otro ✓ 1gal MM liquido ✓ 1 gal alcohol (o guaro casero) ✓ Agua para completar estañón de 200 lt	No importa el orden de los productos, se mezcla todo, agregar agua para completar estañón de 200lt, y se tapa. **<u>En 15 días</u>** ya se puede usar, pero entre más tiempo mejor. Se guardan estañones con tapa hermética para usar después. Hasta 3 años se puede guardar. Poner etiqueta con fecha de elaboración y nombre del producto.	Aporta: minerales, control insectos, nematodos, y hongos (Fusarium, Rhizoctonia, Sclerotinia). **Cada 8-22 días**, Aplicación: **en hortalizas usar 200 cc/bomba 18 lt** (Foliar y al suelo). **En frutales** usar: 1 gal/200 lt. Antes de sembrar papa aplicar al suelo.
11. Insecticida-Nematicida a base de Reina de la Noche (**60 lt**)	✓ 6 kg (Un balde)Reina de la noche (floripondio picada). ✓ 1 lt melaza o caña, o te de frutas, o mermelada etc.	Picar la reina de la noche, agregar melaza, mas 3 lt de MM liquido,o mas y agregar agua para rellenar estañón de 60 lt. Tapar y Dejar 8 días para que esté listo.	Se aplica al suelo al 50% mas 20% agua. Se puede aplicar al 100%. Usar antes de la siembra. Aplicar en forma foliar para mosca blanca: 0.5 lt/bomba 18 lt.

Insumo a preparar	Materiales	Preparación	Aplicación
	✓ 3 lt MM o mas ✓ **Agregar agua para llenar estañón de 60 lt.**		Se puede guardar 3 meses. Usar con cuidado puede dañar lombrices, o bajar la dosis. **Receta 2**: dejar 1kg de reina de la noche en 150 cc de alcohol por 8 días, dosis: 150 cc/bomba (insecticida-nematicida).
12. **Adherente** o Penetrante a base de Sábila (60 lt). 	✓ 6 kg sábila picada (o linaza, o tuna, almidón de yuca, etc) ✓ 1 Litro melaza mezclado con agua ✓ 3 lt MM liquido ✓ Agua para llenar estañón de 60 lt.	Picar sábila, agregar melaza, MM líquido, y agua para llenar estañón 60 lt. Tapar y esperar 8 días.	Aplicar 0.5 lt/bomba 18lt , al 10%. Se puede mezclar con otros Bioles como pega.
13. Bioestimulante a base de **ortiga** (200 lt). 	✓ 20 kg de Ortiga (Urtica dioica) bien picada (**aporta unos 52 minerales**) ✓ 1 gal Melaza y agua. ✓ 20 lt MM líquido ✓ Agua para llenar Estañón. (En lugar de ortiga también se pueden usar malezas que son difíciles de eliminar, brotes tierno de bambú, zabila)	Picar hojas de ortiga y meterlas en una malla, agregar melaza, MM líquido y agua para llenar estañón de 200 lt. Tapar y **esperar 8 días** a que esté listo para aplicar.	Beneficios: estimulante de raíz, da vigor, también controla **pulgones, ácaros y áfidos.** Dosis hortalizas: 1lt/bomba 18lt, al inicio de cultivo. Después aplicar cada 15 días al follaje, a razón de 300 cc/bomba. En café y frutales : aplicar 3lt/bomba cada 3 meses . Se puede almacenar hasta 2 meses.
14. **Bioinsecticida APICHE** (Pichinga de 20 lt) 	✓ 0.5 kg Ajo en polvo (Mercado). ✓ 0.5 kg pimienta negra o blanca molida. ✓ 0.5 kg chile picante ✓ 1lt alcohol (o guaro chirrite) ✓ Mas MM liquido para completar 20 lt	Agregar ajo en polvo, pimienta, chile picante, alcohol, y MM líquido para completar pichinga de 20 lt. Tapar estañón con tela para que no entren insectos, y en 15 días está listo para usar.	Para controlar: **mosca blanca, ácaros, trips, áfidos, picudo**. Dosis hortalizas: 100 cc/bomba 18lt. Aplicar cada 11 o 15 días. Dosis café y frutales: 1lt/ estañón 200lt. Excelente para control de **broca de café, y trips**.

Insumo a preparar	Materiales	Preparación	Aplicación
24. Control de babosas con sal mineral y carbonato de sodio.	✓ Bomba 18 lt ✓ 5 gramos de sal mineral (Una cucharadita pequeña) ✓ 5 gramos de bicarbonato de sodio. (Una cucharadita pequeña).	En un recipiente agregar 18 lt de agua, agregar 5 gramos de sal mineral, mas 5 gramos de bicarbonato de sodio, mezclar todo muy bien, y colar bien para no tapar boquillas de la bomba.	Fumigar toda el área donde haya babosas. Esta mezcla no afecta el cultivo.
25. Insecticida con Detergente o jabón azul	✓ Paq. 120 gs detergente biodegradable, o jabón azul . ✓ 18 litros de agua ✓ 36 cc de aceite o sábila como pega	Agregar paquete detergente 120gs en una bomba de 18 lt con agua, (Agregar 36 cc de aceite o sábila como pega).	Aplicar en la tarde o en la mañana, cuando haya presencia de insectos dañinos en las plantas, ya sea en frutales u hortalizas. Excelente para control de ácaros, trips, pulgones, hormigas, grillos, babosas, etc.

Fuentes de información:

- Productores orgánicos: Juan José Paniagua, Henry Guerrero, de APODAR, Alfaro Ruiz. (20 años de experiencia en agricultura orgánica).
- JICA (Gobierno de Japón). Curso de agricultura orgánica CR/Japón, junio a setiembre 2012.

Para más detalle contactar a :

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APPENDIX D: AGROCHEMICAL INTERVIEW INSTRUMENT

We used this interview instrument to record information from the 5 interviews held with agrochemical farmers, discussed in Section 3.2.2

1) Información Personal *(opcional)*:
Personal Information (optional):

Nombre y Apellido: **Provincia:**
Género: **Canton:**
Edad: **Distrito:**
Nombre de la finca: **Ciudad:**

2) ¿Qué tamaño de la finca tiene usted?
What size farm do you own?

- Tamaño pequeño (1 - 2 hectáreas)
- De tamaño mediano (2 - 3 hectáreas)
- Grande (mayor 3 has) _____

3) ¿Cuáles cultivos cultiva usted? *(Marque todo lo que corresponda)*
What crops do you grow? (Mark all that correspond)

- Aguacate
- Ajo
- Banano
- Brocoli
- Café
- Caña de Azucar
- Cebolla
- Chile Dulce
- Citricos
- Fresas
- Ganaderia de leche
- Lechuga
- Legumbres
- Papa
- Plátanos
- Repollo
- Tomate
- Zanahoria
- Otros: *(especifique)*
- _____

4) ¿Cuál es su principal cultivo? _____
What is your principal crop?

5) ¿Cuántos kilos de su cultivo principal produce por manzana por ciclo? _____
How many kilograms of your principal crop do you produce per manzana or per cycle?

6) ¿Cuál precio de venta por kilo en época lluviosa? ¿En la época seca? (ahora)
How much do the crops sell for in the rainy/dry season?

Lluviosa: $ ₡ Seca: $ ₡

7) ¿Cuál es el costo por manzana de su cultivo principal en época lluviosa? ¿En la época seca?
What is the cost per manzana of your principal crop in the rainy/dry season?

Lluviosa: $ ₡ Seca: $ ₡

Comentarios

8) ¿Cuáles son las amenazas principales a sus cultivos?
What are the main factors that affect your crops?

- El clima (mucha lluvia/muy seca)
- Desastres naturales
- Las enfermedades
- Calidad del suelo
- Bajos precios

9) ¿Cuáles enfermedades puedan afectar los cultivos?
What plagues/illnesses might affect your crops?

- Torbo
- Mosca blanca-(whitefly), *Bemisia Tabaci*
- Tizon- (*Phytophthora infestans*)
- Polilla de la papa
- Fusarium
- Araña Roja
- Nematodos
- Roya del café
- Broca del café
- Caracol del chayote

Otros: _____

Comentarios

10) ¿Sabes qué significan los colores de etiquetas de agroquímicos?
Do you know what the different colors of agrochemicals mean?

- Sí
- No

11) ¿Qué color es la etiqueta de agroquímicos que usa?
What color of agrochemicals do you use?

- Rojo
- Amarillo
- Azul
- Verde
- Blanco
- No usa agroquímicos

Explicar:

Rojo: Amarillo: Azul: Verde:

12) ¿Sabe sobre las técnicas alternativas? ¿Si sí qué piensa sobre las técnicas?
Have you heard of alternative techniques and if so, what do you think of them?

13) ¿Cuáles técnicas alternativas sabe?
What alternative techniques have you heard of?

- Técnicas orgánicas
- Buenas Practicas Agrícolas (BPA)
- Usa productos biológicos
- Otros: _____

14) ¿Ha escuchado sobre MM (Microorganismos de Montaña) o EM?
Have you heard of MM or EM?

- Sí
- No

15) ¿Si afirmativo, conoces gente lo que usa MM y otras técnicas orgánicas?
If so, do you know anyone who uses MM or the other techniques?

- Sí
- No

16) ¿Que piensan estos productores de las técnicas orgánicas o BPA?
What do farmers think of the alternative techniques?

- Bien
- Neutral
- Indiferente
- Mal

Comentarios

17) ¿Porqué cree que ellos cambiaron de agroquímico a orgánico?
Why do you think they changed from agrochemicals to organic?

- Por ética
- Es más barato
- Razones ambientales
- Por salud
- Recibieron capacitación
- Otros:

Comentarios

18) ¿Los productores sienten que hay presión ejercida por hacer las técnicas orgánicas?
Have other farmers felt pressured (peer pressure) to do these alternative techniques?

- Sí
- No

Comentarios

APPENDIX E: MM INTERVIEW INSTRUMENT

We used this interview instrument to record information from the 11 interviews held with MM farmers, discussed in Section 3.2.2

1) Información Personal *(opcional)*:
Personal Information (optional):

Nombre y Apellido: **Provincia:**
Género: **Canton:**
Edad: **Distrito:**
Nombre de la finca: **Ciudad:**

2) ¿Qué tamaño de la finca tiene usted?
What size farm do you own?

- Tamaño pequeño (1 - 2 hectáreas)
- De tamaño mediano (2 - 3 hectáreas)
- Grande (mayor 3 has)_____
- En Manzanas (posiblemente):

3) ¿Cuáles cultivos cultiva usted? *(Marque todo lo que corresponda)*
What crops do you grow? (Mark all that correspond)

- Aguacate
- Ajo
- Banano
- Brocoli
- Café
- Caña de Azucar
- Cebolla
- Cerdos
- Chile Dulce
- Citricos
- Culantro
- Fresas
- Frijoles
- Ganaderia de leche
- Gallinas
- Lechuga
- Legumbres
- Papa
- Plátanos
- Repollo
- Remolacha
- Tomate
- Zanahoria
- Otros: *(especifique)*
-
- _____

4) ¿Cuál es su principal cultivo ? *(Por favor indique)*
What is your principal crop? (Please indicate)

5) Cuántos kilos de su cultivo principal produce por manzana por ciclo o por semana?
How many kilograms of your principal crop do you produce per manzana or per cycle or per week?

6) Cuál precio de venta por kilo en época lluviosa? En la época seca? (ahora)
How much do the crops sell for in the rainy/dry season?

Lluviosa: $ ₡ Seca: $ ₡

7) **Cuál es el costo de producción por manzana de su cultivo principal en época lluviosa? En la época seca?**
What is the production cost per manzana of your principal crop in the rainy/dry season?

Lluviosa: $ ₡ Seca: $ ₡

Comentarios

8) ¿Qué son las amenazas principales a sus cultivos?
What are the main factors/threats that affect your crops?

- La clima (lluvia/seca)
- Desastres Naturaleza
- Las enfermedades
- Calidad del suelo
- Bajos precios

9) ¿Cuáles enfermedades puedan afectar los cultivos?
What illnesses might affect your crops?

Animalitos:	Hongos:	Otros:
○ Trips	○ Torbo	○ Nematodos
○ Áfidos	○ Raíz Rosada	○ Caracol del chayote (snail)
○ Jogoto (larva)	○ Tizon (Phytophthora)	
○ Mosca Blanca	○ Fusarium	
○ Araña Roja (Ácaros)	○ Roya del café	
○ Broca del café		

Comentarios

10) ¿Está utilizando solamente MM?

Do you only use MM?

- Sólo MM y técnicas orgánicas.
- Sólo insumos sintéticos (agroquímicos)
- Algunos MM y algunos insumos sintéticos
- Nada

11) a. ¿Usa agroquimicos usted?

Do you use agrochemicals?

- Sí
- No

11) b. ¿Qué significan los colores diferentes?

What do the different agrochemical colors mean?

- Rojo_____
- Amarillo_____
- Azul_____
- Verde_____
- Blanco _____

11) c. ¿Qué color es la etiqueta de agroquímicos que usa ahora o en el pasado?

What color is the label of agrochemicals that you use/used to use in the past?

- Rojo
- Amarillo
- Azul
- Verde
- Blanco

12) ¿Cómo están sus cultivos con MM? ¿Están prosperando?

How are your crops growing with MM?

- Pura Vida!
- Muy bien
- Bien
- Regular
- Mal
- Muy mal

Comentarios

13) ¿Qué temas se discutieron ustedes en las capacitaciones?
What topics were discussed during the trainings?

- MM
- Bokashi
- Compost
- Biofertilizantes
- M5
- Apichi
- Ortiga
- Biopesticidas
- Otros:_____

14) ¿Cuando se tomó las capacitaciones de MAG?
When was the training? (Date)

Fecha:_____

Comentarios

15) ¿Cuántos agricultores estaban a las capacitaciones?
How many other people were present in the trainings?

Comentarios

16) ¿Desarrollo amistades con los otros productores?
Did you develop friendships with the other trainees/farmers?

- Sí
- No

Comentarios

17) Describe su satisfacción con las capacitaciones del MAG en técnicas de MM. ¿Disfruta usted las capacitaciones?

Describe your satisfaction with MAG's trainings of the MM techniques. Did you enjoy the trainings?

- Pura Vida!
- Muy contento
- Contento
- Mas o menos contento
- Descontento
- Muy descontento

Comentarios

18) ¿Por que cambia de agroquímicos a técnicas de MM?

Why did you change from agrochemicals to MM?

- Por éticas
- Es más barato
- Razones ambientales
- La salud
- Otros:

Comentarios

19) ¿Qué piensa su esposo/esposa o familia sobre las capacitaciones?

What does your husband/wife or family think?

- Les gustan
- Es más difícil
- Toma más tiempo
- Es beneficioso
- No tiene beneficios
- Indiferente

Comentarios

20) a. ¿Tiene empleados?
Do you have employees?

- Sí
- No

b. ¿Cuál son los pensamientos de sus empleados/compañeros de trabajo sobre su cambio a MM y su participación en las capacitaciones?
What do your employees/partners think of your change to MM and your participation in the trainings?

- Les gustan
- Es más difícil
- Toma más tiempo
- Es beneficioso
- No tiene beneficios

Comentarios

21) ¿Que piensan los otros agricultores vecinos de la zona/región?
What do other farmers in your co-op/area think?

Comentarios

22) ¿Es fácil a obtener los MM? ¿Ud. necesita que viajar lejos para obtenerlos?
Is it easy to obtain the MM? Do you need to travel far to collect them?

- Sí
- No
- A veces
- No hay bosque cerca
- Bosque contaminado con mucha basura
- Otros: _____

23) ¿Cuáles son los factores que afectan su capacidad para usar MM?
What factors affect your ability to use MM?

- Hay limitaciones de geografía o de recursos cuando está usando MM
- El clima-La época: lluvia, seca
- Es muy difícil para implementar
- Recipientes/Materiales (metalicos o plasticos)
- Más facil usar quimicos
- Otros:_____

24) ¿Vende más cultivos porque la gente saben que son orgánicos?
Do you sell more crops because people know they are organic?

- Sí
- No

Si sí, cuántos más?
If yes, how much more?
Comentarios

25) **¿Han cambiados los precios de venta de sus productos en el mercado porque son orgánicos? ¿Cómo?**
Has the price of your crops changed in the market because they are organic? How?

- Precios más altos
- Precios más bajos
- Iguales

Comentarios

26) ¿Son los costos de producción más bajos?
Are there lower production costs?

- Sí
- No

27) ¿Sabe qué porcentaje de reducción?
Do you know the percentage of reduction?

28) ¿Está contento con los resultados de MM?
Have you been pleased with the results?

- Sí
- No

29) ¿Los cultivos tienen un sabor diferente/mejor?
Do your crops taste different/better?

- Sí
- No

30) ¿Los cultivos crecen mejor o con mejor salud?
Do crops grow better/healthier?

- Sí
- No

31) ¿Se evitan los insectos y plagas?
Are insects and plagues kept away?

- Sí
- No

32) ¿Ha mejorado la calidad del suelo? ¿Cómo lo sabe? ¿Tiene análisis del suelo?
Has the soil quality improved? How do you know? Do you have soil analysis?

- Sí
- No

Comentarios

33) ¿Piensa que los cultivos son mejor para la salud de las personas con técnicas orgánicas?
Do you think that the organic crops are better for the health of the people?

- Sí
- No

34) Hay muchas investigaciones sobre cáncer y el uso de agroquímicos. ¿Conoce a un productor quien tiene cáncer o problemas con la fertilización y usa agroquímicos?
There is a lot of research about cancer and the use of agrochemicals. Do you know of a producer that has cancer or fertility problems and uses agrochemicals?

- Sí
- No

Comentarios

35) ¿Hay una diferencia/mejoramiento en la calidad del aire desde se usa MM?
Is there a difference/betterment in air quality since you use MM?

- Sí
- No
- No sé

36) ¿Nos recomienda algo para las capacitaciones o las técnicas orgánicas?
Do you have any Recommendations about the trainings or the organic techniques?

Video

- **¿Podemos sacar un video corto de usted hablando sobre las capacitaciones y MM?** *Can we get a short clip of you speaking about the trainings?*
- **Por favor, dinos una declaración personal sigue la experiencia con MM.** *Make a personal statement about your experience with MM.*
- **Dinos algo interesante que aprende.** *Tell us something interesting you learned.*
- **¿Cuáles recomendaciones tiene para MAG?** *What recommendations do you have for MAG?*

APPENDIX F: PROMOTIONAL VIDEO FOR MAG

We created a promotional video for MAG to shows the opinions of farmers on MM and the training program. All footage was recorded during interviews and focus groups during farm visits. This video can be found at https://youtu.be/4sRGI9Rcsjc

APPENDIX G: CONSENT FORM

This consent form was signed by all farmers who participated in interviews and focus groups. It was reviewed by Ing. Tencio prior to dissemination.

Forma de Participación

Nosotros somos cuatros estudiantes de Worcester Polytechnic Institute en los Estados Unidos. Estudiamos las técnicas diferentes de agroquímicos en el Región Central Oriental para avisar a MAG como mejorar los servicios a los agricultores. Si quiere participar en nuestro estudio, vamos a preguntarle sobre sus opiniones y perspectivos sobre las técnicas. Hay preguntas sobre información de geografía, social, conductual, y económico. Vamos a recoger la información de identificación, de opiniones y de las observaciones sobre las técnicas.

Esta totalmente de acuerdo en participar. Usted se puede retirar en cualquier momento y usted puede omitir alguna pregunta. Incluso si no quieres ser grabado, todavía nos gustaría tener la oportunidad de entrevistarlo.

La información de este estudio es solamente para el uso de nuestra investigación entre El Ministerio de Agricultura y Ganadería (MAG) y Worcester Polytechnic Institute. Toda la información será confidencial.

Quisiéramos preguntar si sea posible grabar sus respuestas para nuestro estudio. *Por favor conteste las siguientes preguntas con lo mejor de su capacidad. Parte de esta información es opcional y por lo cual no están obligados/as a contestar.*

Firmar_____

Nombre de productor _____

APPENDIX H: FOCUS GROUP INSTRUMENT

This instrument was used to guide focus group discussions, as described in Section 3.2.3.

1. Introductions: Names, Farms, Location, Fun Fact
2. **¿Cómo fueron sus experiencias con las capacitaciones?**
    a. *What were your experiences like with the trainings?*
    b. **¿Han desarrollado amistades con otros productores?** *Have you made friends?*
    c. **¿Cuáles técnicas orgánicas aprendieron?** *What techniques did you learn?*
    d. **¿Cómo influenció en sus relaciones con otros productores? ¿Con empleados? ¿Con su familia?** *Does it influence relationship with your neighbors, friends, or family?*

3. **¿Cómo funciona el programa de MM para ustedes?** *How is MM working for you?*
    a. **¿Solamente usan MM o usan agroquímicos también? ¿Porque?** *Are you using only MM or agrochemicals too?*
    b. **¿Cómo han cambiado sus ingresos de cultivos?** *How have your crop yields changed?*
    c. **¿Cómo han cambiado los precios de cultivos?** *How have prices changed?*

4. **¿Hay cambios en el ambiente desde que empezaron usar MM?** *How has the environment changed since using MM?*
        i. **¿Hay una diferencia en el agua/aire/suelo?** *Is there a difference in water/air/soil quality?*
        ii. **¿Hay macroorganismos en el suelo?** *Are there more macroorganisms in the soil?*
        iii. **¿Cómo cree que cambio la calidad del suelo? ¿De la gente**? *How has the health of the earth changed? Of the people?*

5. **¿Cómo han cambiado sus vidas desde las capacitaciones?** *How have the trainings changed your life?*
    a. **¿Qué aprendieron de la experiencia de las capacitaciones de MM?** *What have you learned from this experience?*
    b. **¿Su Mentalidad cambió después de las capacitaciones? ¿Cómo?** *How have these trainings changed your mindset?*
    c. **¿Las dinámicas de sus comunidades cambiaron después de las capacitaciones?** *Have the dynamics of your communities changed due to your participation in this program?*

6. **¿Recomendaría usted la participación en las capacitaciones a otros productores? ¿Porqué sí o porqué no?** *Would you recommend other people to participate in the trainings? Why or why not?*
    a. ¿Las técnicas de MM serán una buena opción para mejorar el nivel de la vida? *Are the organic techniques a good option to improve the quality and level of life?*
7. **¿Tienen algunas recomendaciones para mejorar esta capacitación de MM?** *Do you have other recommendations to improve this training of MM?*

APPENDIX I: OBSERVATION INSTRUMENT

We developed this instrument partway through the study to have more uniformity among observations made at farms. More information is included in Section 3.2.4.

Name of Farm/Farmer: Date:

SOIL:

- Macroorganisms:
- Moisture:
- Color:
- Smell:

WATER:

- Type of Irrigation Systems:
- Water Sources:
    - Color/Turbidity/Organisms:
    - Quantity/Location:

CROPS:

- Leaves:
- Fruit:
- Roots:
- Size:
- Color:
- Variety:

FARMERS: What are they passionate about?

APPENDIX J: RAW DATA FROM MM INTERVIEWS

This Appendix has data tables compiled through content analysis of interview reports from MM farmers.

Table 4. Background information for MM farmers

Farm Name	Question 13						Question 14				Question 15	
	MM	Bokashi	Compost	Biofertilizers	Biopesticides (indicate)	Others	Months	Year	W/TENCIO	W/OTHER	# of people	Size
1	X	X	X	X	X - M5		June-Aug	2014	X		18	M
2	X	X	X		X - Chile Picante		June-Aug	2014	X		18	M
3	X	X		X -Chile			June-Aug	2014	X		18	M
4	X	X	X - Abonos				Dec	2012	X		15	M
5	X	X		X		MANURE				X - Dad	N/A	
6	X	X	X					2013-2014	X			
7	X	X	X			WORM COMPOST OTHER TRAINING	2 trainings	2013	X		50	L
8	X	X		X	X - M5		Feb-Apr	2015	X			
9	X	X	X	X	X - m5, apiche							
10	X	X	X- (abono)		X- M5	COMPOST THRU CATIE TRAINING	August (1 d	2014	X		100	L
11	X				X-M5	ANIMALS	Oct-Dec	2012	X		12	S

Data Regarding MM Techniques

Table 5. MM farmers' opinions of MM

Farm Name	28-Have you been pleased with the results of MM?		29-Do crops taste different/better?		
	Yes	No	Yes	No	N/A DO NOT KNOW
1	Y			x	
2	Y		x		
3	Y				x
4	Y		x		
5	Y				x
6	Y		x		
7	Y		x		
8	Y				x
9	Y		x		
10	Y		x		
11	Y		x		
Total	11	0	7	1	3
Percentage	100%	0%	63.6%	9.1%	27.3%

Table 6. Farmers' experience using MM

Question	10 Do you only use MM?				22 Is it easy to obtain MM?					22
Farm Name	Solo MM y organic	Solo agroquimicos	Mezcla	Nada	Si	No	A Veces	No Hay Bosque Cerca	Bosque Contaminado	Comments
1			x		x					
2	x				x					
3	x				x			x		
4	x				x					Follow the guide and theory!
5	x									
6	x				x					mas barato
7			x		x					90% of resources needed are found on farm
8	x				x					
9	x				x					
10			x		x					
11			x		x					

Table 7. Factors that affect farmers' ability to use MM

Question	23 What effects your ability to use MM?						23
Farm Name	Geografia o rcoursos	Clima/epoch a	Dificil	Mas Facil Usar Quim icos	None	Otro	Comments
1		x					
2					x		consciousness only about nature, he was learning to become one with mother earth.
3						x	la sombra
4					x		She uses California red worms (lombrices) that were brought to her from Texas by a friend. They need shade. MM makes soil wetter and looser so the worms can get to it more and access it.
5	x	x					Need containers
6					x		Very easy!
7					x		
8		x					grow better in the summer, less illness but they have to irrigate/floods in the winter -they control it though
9					x		
10					x		He lives on a mountain, so it is easy
11	x	x					Time is a huge limiting factor

Data Regarding MM Trainings

Table 8. MM farmers' opinions of MAG's MM trainings

Farm Name	Question 16 (friendships)		Question 17 (enjoy trainings)					
	Yes	No	Pura Vida	Muy Contento	Contento	Mas o Menos	Discontento	Muy Discontento
1	X			X				
2	X		X					
3	X			X				
4	X		X					
5								
6	X			X				
7	X				X			
8				X				
9	X			X				
10	X		X					
11	X		X					

MM Interview Environmental Data

Table 9. Presence of pests with MM

Farm Name	31-Are insects kept away with MM?			32-Has the soil quality improved with MM?		35-Is there a difference towards the better in air quality?		
	Yes	No	N/A	Yes	No	Yes	No	N/A/DO NOT KNOW
1	Y			Y		Y		
2	Y			Y		Y		
3	Y			Y		Y		
4	Y			Y		Y		
5			X	Y				X
6	Y			Y		Y		
7	Y			Y			N	
8	Y			Y				X
9	Y			Y		Y		
10	Y			Y		Y		
11	Y			Y		Y		
Total	10	0	1	11	0	8	1	2
Percentage	91%		9.0%	100%		73%	9.1%	18%

Table 10. Factors that affect crop production

Farm Name	Question 8 (main factors affecting crops)					
	Climate	Natural Disasters	Plagues	Soil Quality	Lower prices	Turrialba
1	1		2			
2	1		2			
3	1		2			
4	2		1			
5	1					
6	1					
7	1		2			
8			1			
9	1		2			
10			1			
11	2		1			3

MM Interview Economic Data

Table 11. Production costs of principal crops for MM farmers

Farm Name	Question 7 (Production cost of principal crop)			
	Lluviosa	Seca	Yearly cost	Monthly Cost
1	N/A		N/A	N/A
2	₡ 100,000/year		100,000 ₡/year	8,333.3 ₡/month
3	Variable		Variable	
4		₡0/month, 2000 c/kilo small bags, large bags :8500 c/3000 plants	87,000 ₡/year	7,250 ₡/month
5		₡30,000,000/ year	30,000,000 ₡/year	2,500,000 ₡/month
6	before: 80-100,000 ₡/fenega/year , after: 60,000 ₡/fenega/year		60,000 ₡/fenega/year	5,000 ₡/fenega/month
7	70% less cost			
8		₡4-5,000/month	48-60,000 ₡/year	4-5,000 ₡/month
9	almost 0		0	
10				
11	45% of selling price	35% of selling price	rainy: 15,660,000 ₡/year dry: 12,180,000 ₡/year	rainy: 1,305,000 ₡/month, dry: 1,015,000 ₡/month

Table 12. Redkuction in production costs for MM farmers

Farm Name	Question 26 (Are there low production costs)		Question 27 (Percent reduction)
	Yes	No	
1	Y		60%
2	Y		70%
3	Y		20%
4	Y		70%
5			
6	Y		60%
7	Y		70%
8	N/A		N/A
9	Y		50%
10	Y		57%
11	Y		60%

Table 13. Sales of MM crops

Farm Name	Question 6 (How much do you sell crops for)		Question 24 (sell more b/c organic?)		Question 25 (has price of crops changed b/c organic?		
	rainy	dry	Yes	No	Higher	Lower	Same
1	a lot is lost	sells to feria: 1400 c/kg , feria sells for 2000 c/kg	Y		X		
2	3000 c/kg	2500 c/kg to middlewoman	Y		X		
3	1000 c/kg	500 c/kg	Y		X		
4		agrochemicals: 600 c/kg , organic: 1000 c/kg , 2500 c/plant bag		N	X		
5	N/A	$ 700-800/ton		N			X
6	exports: 500-2,000$/fanega , non exports: 100,000 ₡/fanega		Y		X		
7	800 c/kg	1000 ₡/kg apples	Y				X
8	N/A		N/A		N/A		
9	1000-1500 ₡/kg asparagus			N	X		
10	café: 50,000 ₡/fanega , cana 20,000 ₡/ton			N			X
11	290 ₡/kg milk		Y				X

Table 14. MM crop yields

Farm Name	Question 5 (how much of principal crop produced?)
1	600 kg/week uchuva
2	493 kg/week frijoles
3	300 kg/ week vainica
4	125 kg/week
5	10 kg
6	973 kg/week
7	
8	300 kg/week
9	25 kg/week, 560 kg/week exp. tomatoes
10	cana: 1,346 kg/week cafe (last year): 31 kg/week
11	2,500 kg/week milk

Table 15. Farmer's opinions of crops grown with MM

Farm Name	12-How are the crops growing with MM?						30-Do the crops grow better/healthier with MM?	
	Pura Vida	Muy Bien	Bien	Regular	Mal	Muy Mal	Yes	No
1		x					Y	
2	x						Y	
3		x					Y	
4	x						Y	
5		x					Y	
6	x						Y	
7		x					Y	
8	x						Y	
9	x						Y	
10	x						Y	
11	x						Y	
Total	7	4	0	0	0	0	11	0
Percentage	63.6%	36.4%	0%	0%	0%	0%	100%	0%

MM Interview Social Data

Table 16. Other peoples' opinions of MM

Farm Name	Question 18 (Change to MM)					Question 19 (husband, wife family think)						Question 20 (employees)	
	Ethics	Cheaper	Environmental	Health	Other (indicate)	Les gustan	Deficil	Mas tiempo	beneficioso	no beneficiosos	indiferente	Yes	No
1		1		2		X							N
2		1		1		X							N (family)
3		2		1		X							N
4	5	4	1 (better soil)	2	oduct quality for consu	X (dad)	X - (brother is skeptical)						N (family)
5	2	3	1	4		X			X			Y	
6		3	1	2		X						Y (2)	
7		1		2		X						Y	
8	USED MM FROM START					X			X			Y	
9		2	2	1		X							N
10		1	2	3	4 (convenience)	X							N
11		2	1 (pollution+ soil	3					X				

Table 17. Health effects of agrochemicals according to MM farmers

Farm Name	33-Are the organic crops better for the health of the people?		34-Do you know anyone with cancer because of agrochemical usage?	
	Yes	No	Yes	No
1	Y			N
2	Y		Y	
3	Y			N
4	Y		Y	
5	Y			N
6	Y			N
7	Y			N
8	Y			N
9	Y			N
10	Y		Y	
11	Y			N
Total	11	0	3	8
Percentage	100%	0%	27.5%	72.5%

Table 18. Opinions of employees and families regarding MM

Farm Name	Question 20b (employees thoughts)					Question 21 (other farmers thoughts)
	Les Gustan	mas dificil	takes more time	beneficial	not beneficial	
1						They are happy. Health is important and they all like the organic techniques.
2						"cambio completamente radical y muy bueno" No longer killing people
3						all on the coop agree
4						they only use agrochemicals, money oriented→ ask if she needs help with agro
5	X					in the beginning they thought they were crazy,they saw changes and they liked it
6	X					they don't believe in the technique, but she shows them her crops. Still many aren't convinced
7	X	they don't like the smell of the rabbit scat				other use 60/40 % and if they can't use MM to control they use agrochemicals
8	X					farmers in his area really like it
9						parcelas, all work together, united, a community, very connected and happy, people who don't use are suspicious
10						they are happy.
11						it's a process- hard to get used to

Table 19. MM farmers' use of agrochemicals

Question	10 Do you use only MM?				11 (a) Do you use chem?		11 (c) (which are/were used?)				11 (b) What do colors mean?	11 Comments	
Farm Name	Solo MM y organic	Solo agroquimicos	Mezcla	Nada	Y	N	Rojo	Amarillo	Azul	Verde			
1			x		x			x			Red is very very bad	Uses synthetic agrochemicals for chayotes; onl y uses MM for chiles y vainica to test it out	
2	x				Y		x	x	x	x	Red is deadly	Use agrochemicals only when they plant seeds. He used all of them because the stupid engineers from California told him what to use. Contaminated the land, killing the good things in the soil. "We were idiots for listening to them"	Used fungicides- black label- contaminates water, no legal in the US.
3	x				Y						Red is dangerous	He uses Blanco - tencio didn't know what this was	
4	x					N				x	Red is a killer	Used green becasuse they had to harvest every few weeks	
5	x					N						Used to use chemcials, but he didn't know whick	
6	x					N						Used to use chemicals	
7			x		Y					x	Different colors are used to control different pests	Does Not use RED	
8	x					N							
9	x					N							
10			x		Y					x		Used all colors to fight some diseases, but none worked.	
11			x		Y		x	x	x	x	Red is extremely dangerous and smells bad	Only uses chemicals in extreme weather and plagues. 60% MM, 40% Chem. 90% green, 5% blue, 4% yellow, 1% red	

APPENDIX K: RAW DATA FROM AGROCHEMICAL INTERVIEWS

We compiled these data tables while analyzing the content of interviews with agrochemical farmers

Agrochemical Economic Raw Data

Table 20. Agrochemical production costs

Name	Question 8 (Production cost of principal crop)	
	Lluviosa	Seca
1	$600/week , 2 ha strawberries/week costs 200,000 - 300,000 ₡ , farms sell for 720-750 ₡ /kg markets sell 3,000 ₡ /kg	
2	2,000,000 ₡ /manzana/ciclo	4,000,000 ₡ /manzana/ciclo
3	250,000 ₡ /week/mediamanzana	
4	1,000,000 ₡ /ciclo in general	
5	no current prices b/c recently started Dr. Obregon	

Table 21. Agrochemical crop selling prices

Name	Question 6 (How much do you sell crops for)	
	rainy	dry
1	750 ₡/kg profit	650 ₡/kg profit
2	400 ₡/kg from farm, sold for 600 ₡/kg	
3	700 ₡/kg	550 ₡/kg
4	350-400 ₡/kg onion	400 ₡/kg onion
5	N/A	

APPENDIX L: CONSUMER STUDY INSTRUMENT

This is a guide we developed to aid MAG in conducting a future consumer study. We originally hoped to complete a short consumer study, but we unable to due to time constraints.

Age: Gender: Education Level:

Location of Survey:

What factors do you consider when buying produce?

- Cost
- Quality
- The means of production
- Organic certification
- Place of purchase

Where do you purchase fruits and vegetables?

- Automercado
- Fresh Market
- AM/PM
- Musimanni
- Fruit Carts
- Mas x Menos
- Pequeno Mundo
- Other small stores

If a product is labeled “organic” does that affect your tendency to purchase it over other products?

- Yes
- No
- Sometimes
- Why?

Which farming techniques have you heard of?

- Buenas Practicas Agriculturas
- Sustainable irrigation
- Hydroponics
- Biodigestors
- Compost
- Lombricompost
- Dr. Obregon
- Effective Microorganisms
- Mountain Microorganisms