

Sustainable Horticulture Crop Production in the Bahamas

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Introduction

The Bahamas is officially named The Commonwealth of the Bahamas and is a country located just to the southeast of Florida and north of Cuba. It is comprised of over 700 islands varying greatly in size. I chose this country because I have been there before and wanted to do a country that I have been to. I also want to learn more about plants that grow in a different climate from ours in Minnesota.

The entire country is very low and flat. The highest point is located at the top of Mount Alvernia only 210 feet above sea level. The rest of the country has hills that are around 50 to 65 feet in elevation. The subtropical climate is moderated by the waters of the Gulf Stream, however these waters are very dangerous and have led to several fatal hurricanes in the country (CIA, 2009).

The population is rather low largely due to the fact that the tourism industry is large. A population of 310,000 (July 2009 est.) is an estimate based on a high mortality and low birth rate due to AIDS. An estimated population growth of .925 is given because of the high amount of AIDS infected people (CIA, 2009). The dominant ethnicity is black at 85% followed by white at 12%.

The economy is almost completely driven on tourism. Construction and running of new hotels account for half of the labor force and 60% of the GDP. With a GDP of

\$9.086 billion (2009 est.), 3% of that is used in the agricultural field. Limited space limits the ability to be a large exporter and thus the Bahamas are ranked very low in exporting moving around \$674 million per year (2006 est.).

The labor force is slightly greater than half of the population at 175,500 with 50% of those people in the tourism industry and 5% in agriculture. The Bahamas has a relatively low unemployment rate at 7.6%.

Being that the Bahamas is comprised almost entirely of flat land, the field of agriculture is hard to get developed. When hurricanes and heavy rains come in large areas of land are destroyed by the salt water and other debris that gets blown around. This makes things very difficult when trying to establish an industry that could reduce the amount of imports that are brought in daily. 80% of the food consumed in the Bahamas is imported, totaling \$2.401 billion (2006 est.). The climate is amazing for citrus plants and other heat loving crops. Much of the crop production is done through potting methods due to the bad soil. In the past few decades, an effort has been initiated to turn to sustainable practices when developing and producing crops.

Sustainability

The Commonwealth of the Bahamas runs into many problems when trying to become sustainable because of its location in regards to the oceans and the hurricane beltline. As mentioned hurricanes and heavy rainfalls are frequent disasters on the islands. When these events occur a lot of debris and salt is brought onto the land and

leached into the soil. Alongside this is also the process of the water moving minerals that are added to the soil during crop production i.e. fertilizers and pesticides. This mineral movement is not as large of a risk on lands that only see very heavy rainfall maybe once a year lowering runoff damages. But in the Bahamas heavy rain is frequent and freshwater supply is rather scarce. A push towards something more sustainable has been in the works for a few years now and is being greatly supported by the government through incentives.

One definition of sustainability found was:

“Sustainability is an economic, social, and ecological concept. It is intended to be a means of configuring civilization and human activity so that society and its members are able to meet their needs and express their greatest potential in the present, while preserving biodiversity and natural ecosystems, and planning and acting for the ability to maintain these ideals indefinitely. Sustainability is providing for the best for people and the environment both now and in the indefinite future. Sustainability affects every level of organization, from the local neighborhood to the entire globe. Strategy can be implemented and systems under it effectively maintained through planning and the provision of necessary financial, infrastructural and human resources (National Biosecurity Strategy).”

I thought this definition was very vague. There is no direction to this definition and no goal. Maybe with the lack of agricultural ability throughout the land the vagueness is purposeful. The National Biosecurity Strategy has defined sustainability as:

“Sustainable use is the use of biological resources in a way and at a rate that does not lead to the long-term decline of biodiversity. Sustainable use therefore maintains the potential of biological resources and thus biodiversity to meet the needs and aspirations of present and future generations (National Biosecurity Strategy).”

This to me is a decent definition. It focuses on biodiversity but is rather vague in not including what practices should and should not be done. To me these definitions

combine to make an overall goal of harvesting and operating in such a manner that in years to come the farmers and workers in general will be able to do the same with the same amount of resources. Preventing the depletion of the resources that the country has to offer and the practice of new techniques that help replenish the land with nutrients will be important for this movement.

The government has stepped in to help stimulate the country into becoming more sustainable with the additions of different agencies, corporations and acts. One of the major corporations that have been involved in this process is the Bahamas Agricultural and Industrial Corporation (BAIC). They came up with an act in 1981 to help boost the agricultural industry.

Bahamas Agricultural and Industrial Corporation Act 1981

- To stimulate, facilitate and encourage the development of agriculture in the Bahamas;
- To process the produce of agriculture in The Bahamas; process being defined as milling, canning, packaging, and preparing agricultural produce for market;
- To market the produce of agriculture within or outside The Bahamas
- To carry out operate and participate in any agricultural projects as the Minister may approve;
- To assist in the creation and development of commerce and industry in the Bahamas; and
- To expand and create opportunities for Bahamians, to participate in the economic development of the country. (Agriculture in the Bahamas, 2008)

Historical Production Practices

Crop production is almost entirely for home use so production practices are very irregular. Most production is done in pots because little arable land that is available on

the islands. Glasshouse construction was not started until the 1990s in the Bahamas and there is only one commercial glasshouse grower in the country. Very little data and information are recorded on historical production practices.

Slash and burn techniques were used by the Lucayans when the country was first being established. This technique is not typically done anymore because of the negative effect it has on the soil. Slash and burn consists of cutting down and burning the crops after harvest and is typically used as a means of shifting cultivation. They would use up all the nutrients in the plot of land and then slash and burn the field and use it for livestock or wood production. These poor production techniques have led to the 80% importation of food because the land is becoming less and less arable.



Figure 1: Slash and burn technique used by the Lucayans
http://en.wikipedia.org/wiki/Slash_and_burn

Production Statistics

Crop production has been on the rise in recent years due to the recession and increasing costs of importing. Many organizations are trying to develop a nationwide standard of “Go Green, Go Bahamian.” Most of the crop production to date is done for family and small scale use only. There are very few large-scale agriculture producers, with the majority of them being on the islands of Northern Bahamas, most agricultural products are consumed domestically.

Following an outbreak of citrus canker on Abaco in 2005, The Bahamas lost a main agricultural export, and the Ministry of Agriculture banned the export of plant materials from Abaco. The Bahamas imports more than \$250 million in foodstuffs per year, representing about 80% of its food consumption.

Historically there were very few different crops grown throughout the islands (citrus (grapefruit (*Citrus paradise*)), coconuts (*Cocos nucifera*), corn (*Zea mays*), onions (*Allium* spp.), pineapples (*Ananas comosus*), sweet potatoes (*Ipomoea batatas*), tomatoes (*Solanum lycopersicum*)) but now many different species (tomatoes (*S. lycopersicum*), sweet & hot peppers (*Capsicum* spp.), citrus (*Citrus* spp.), pumpkin (*Cucurbita pepo*), sweet potato (*Ipomoea batatas*), watermelon (*Citrullus lanatus*), thyme (*Thymus vulgaris*), bananas (*Musa* spp.) and many more) are grown as well as several with different varieties (Cleare, 2010). Approximately 1.4% or 34,600 acres (14,000 ha) of the land is considered agricultural and only .8% or 20,000 acres (8,100 ha) considered arable land. It was estimated in 1994 that there were 1800 farms in production throughout the islands. The majority of farmland is found within three of the islands; Andros, The Abacos, and Grand Bahama Island. More than 5,000 of the total acreage is designated for the Bahamas citrus crop. In 2008 the Bahamas exported \$935,000 worth of fruits to the U.S. (FTD-Statistics, 2009).

Current Production Practices

Crop production in the Bahamas has been a vicious struggle for many years. With several challenges like inadequate production systems, lack of information technology, poor infrastructure, environmental constraints, foreign competition and weak

access to international markets make it almost impossible to start a solid, growing business in agriculture (Minns, 2005). The effects of hurricanes on the agricultural community are devastating and only add to the constant pitfall of crop production. It's a great risk that only few are willing to gamble.

There are several different practices used for crop production in the Bahamas. The most common practice being field production with methods of slash and burn and "pot-hole farming" incorporated within (Cleare, 2010). "Pot-hole farming" is a term used for a practice that is mainly done for domestic use but the farmer sells off the excess crop as a source of income. Because of a lack of arable land this practice is characteristically only feasible on the small scale and mainly for subsistence farming. The greater amounts of farmers are found in the islands of central Bahamas and are either semi-commercial or subsistent farms. The semi-commercial farms commonly use mechanized systems on a small scale such as, tractors, pesticide sprayers and watering systems. A lack of funds and knowledge make it unfeasible to use newer forms of mechanized agriculture, i.e. airplanes, GPS.

Large-scale commercial production is done on the islands of northern Bahamas, namely Abacos, Grand Bahama and Andros. This area is where almost the entirety of export production is done. There are far fewer farmers within this region but the size of the farms is much larger. The only glasshouse in the country is found in this region and is one of the main producers of lettuce, peppers and tomatoes. Typically the commercial producers have sub-sectors in livestock and poultry to aid in income.

Several of the commercial and semi-commercial growers have large hoop houses used to withstand the large amount of rainfall throughout the growing season. This type

of set-up is normally used in our climate to extend the growing season but is effectively used in a different way in the Bahamas.

Lucayan Tropical is a hydroponic greenhouse producer and currently runs the only glasshouse in the country. They are considered one of the greenest growers in the country because of the practices they use. Through their 7-acres of greenhouses they capture all rain water off the roofs and house it in large holding tanks. This is the water they use for production. Having a hydroponic system means that 100% of the water they put out is being taken in by the plants and not being wasted by run-off (Lucayan Tropical Produce, 2010).

The glasshouse is built with galvanized steel and has an aluminum superstructure that was specially built to withstand hurricane damage. The glazing material is glass for this same reason. This is a state of the art facility and the government has high hopes for it to be a start to a boost in agriculture throughout the country.

Lucayan Tropical is also considered the leader of the IPM movement in the Bahamas for the IPM practices that they integrate in their production. They introduce beneficial pests and organisms into their greenhouses that outcompete the negative pests and help produce healthier plants. Another advantage of their system is the use of vertical crop production throughout their greenhouses. They estimate a 20-30 times more yield than conventional farming through this system (Lucayan Tropical Produce, 2010).

Several exporters get a large sum of their income during the winter months that are increasingly shortening the growing season in the US. The Bahamian exporters take advantage and grow the most profitable products (lettuce (*Lactuca sativa*), tomatoes (*Solanum lycopersicum*) and cucumbers (*Cucumis sativus*) that US consumers are

looking for and export them to Florida. The growing season in the Bahamas is virtually year round but is usually counteracted with crop rotation, meaning they grow different crops at different times of the year, mainly circulating around the rain season.

Integration of Historical and Current Production Practices

The only production practice that I could find historically was slash and burn. This practice is highly unsustainable but is still commonly used in the Bahamas today. The lack of knowledge and technology constitutes for such techniques to be continued to be used. They are solely integrating new practices that are sustainable but it's difficult to get farmers to change their practices. Most of the subsistence farmers are old and have been doing it this way for their whole lives.

If more companies can develop systems similar to Lucayan Tropical's, the agriculture industry in the country could have a nice turn-around. The hydroponic/vertical growing system is very space efficient and yields a larger crop. This system is very limited because of the cost of the greenhouse but could be used by some of the large scale producers. There are other more sustainable systems for small-scale growers.

Developing better mechanized farming practices is always possible and is very efficient. Using sustainable techniques with mechanized farming is something that needs to be worked on greatly. Cleaning off the equipment to reduce the spread of disease, and pathogens is something that needs to be expressed at greater levels. Another point to emphasize would be the proper use of the equipment and use in a sustainable manner to do the least amount of disruption to the soil.

From what was found it seemed as if many of the small farms typically have no crop rotation developed. Crop rotation could help in ridding out the use of slash and burn. With no crop rotation the nutrients in the field will quickly be taken up. When this happens, these farmers are doing the slash and burn and wasting several years while the nutrients redevelop so that they can use that plot of land for growing again. If the crops were rotated and proper crops were implemented the nutrients would replenish themselves for the most part.

In terms of small-scale production I believe the most feasible practice that can be used is mechanized farming, implementing different sustainable components with it. This can be done at different cost levels to accommodate different levels of income. The best tractor does not always need to be used and if taught to use a tractor properly this practice can be very efficient and provide a larger yield through faster planting and harvesting. The use of slash and burn techniques needs to be banned from the industry. It is terrible for the soil structure and chemistry and is nowhere near sustainable. With the country going through much economic struggle the agriculture industry is a component that can help in bouncing back immensely. Because there is so much room for improvement within the production practices, foreseeing the amount of economic help the industry can induce is impossible.

The two main crops grown in greenhouse production currently are tomatoes and peppers. Since there is a lack of greenhouse production throughout the country, more research can be done on growing these crops more efficiently and sustainably in a greenhouse. Other crops to look at for greenhouse production would be any winter vegetables. These crops can grow year round in the Bahamas and not in most countries.

This can be a great economic advantage if they can grow them efficiently and on a commercial scale to export to other countries.

Finalized Sustainable Development Strategy

Creating a sustainable production strategy for greenhouse production in the Bahamas is essential for the growth of the economy and agriculture as a whole. History shows that the methods used for farming have nearly depleted the soil nutrients and have made the land unarable. The land has now become so unsustainable that it is unfeasible for commercial production. A logical resolution to overcome this would be greenhouse production.

The solution of simply producing in greenhouses has its challenges. The heat during the summer months would become far too hot in a traditional greenhouse. To combat the heat, a cooling system would need to be run almost non-stop to achieve the appropriate temperature for the plants. The cost in running the system would be uneconomical. There are some alternatives that would need to be introduced in order to make commercial greenhouse production feasible.

Lucayan Tropical uses 100% hydroponics in their commercial greenhouses. This is one way to keep the plants cool because the water is less conductive of heat than soil and also does not hold heat very well. A higher knowledge of hydroponics would be essential for this method of growing especially at a commercial scale.

Another method that could be introduced to reduce energy costs would be the installation of wind turbines to capture wind energy. The Bahamas is an extremely

windy country greatly due to being surrounded by ocean. If properly arranged in the windiest locations the turbines could be very beneficial and help in reducing energy costs.

The benefits of greenhouse production seem to be endless when considering the unsustainability of the land. With large portions of the land being unarable, producing in a greenhouse seems to be the only option for production at a commercial scale. Using appropriate soilless media, greenhouse production could be a gateway to a surge in the economy.

Already having heavy backing from the government, producers should be able to construct greenhouses without worrying about the costs. A government act has already been imposed that provides interest-free loans to all farmers for agricultural equipment, which would include greenhouses. Being a relatively new “experiment” one could imagine that grants and other forms of money may also be available for this.

Some of the gaps that may be misunderstood would mainly evolve around the lack of money that the farmers have. Most of the local farmers are small scale because they cannot afford to produce any larger. If there are grants available to help assist these smaller farms to construct a greenhouse and began sustainable production out of them there would be a lot more cooperation and support.

While most of the farmers throughout the country are very knowledgeable in field crop production, very few have any experience in greenhouse production on any scale. This would have to be something that is taught to the farmers through seminars and training sessions that would need to be held by the government or small organizations that are willing to help. With an economic crisis being seen nationwide and the realization that crops need to be grown for sales within the country, it is believed that

finding this help will not be a problem. There are currently several organizations that help educate farmers on the use of high tunnel systems but the need for greenhouses is becoming more and more of a necessity.

Much research needs to be done in commercial scale greenhouse production mainly in the crops of tomatoes and peppers. With very low numbers of commercial greenhouses in production (only 1 found) the sky is the limit. Research needs to be done in finding the best way to sustainably grow these crops keeping the hot climate in mind. Because the climate is so hot, especially in the summer, different means of cooling will need to be examined as well as different growing media that will help with keeping not only the roots cool but also the greenhouse as a whole.

A good starting point to the research would be finding ways to keep the greenhouses cool at an economically feasible cost. This could be done with a design of a totally new greenhouse that has yet to be constructed or by using greenhouse designs already in production. With the hot climate, this is going to be the biggest issue in making commercial greenhouse production become a reality.

A few questions that will need to be answered through the research experiments will include: What is the best style of greenhouse for commercial production? What growing media grows the most profitable crop in a greenhouse (while keeping sustainability in mind)? What is the most efficient way of cooling, economically and sustainably?

Design a Future Sustainable, Controlled-Environment Production Facility

Cape Eleuthera Institute has started research on different sustainable agricultural methods. Due to heavy slash and burn practices on Eleuthera Island, the land has almost been completely depleted of nutrients. Several scientists and researchers have realized the great economic impacts that agriculture holds on the country and have decided to research ways to rebuild the agricultural field on a sustainable level.

The two fields that the Institute is focusing on are permaculture and aquaculture. Permaculture is a production system that focuses on the system regenerating and supporting itself. It uses a lot of the natural environment and the relationships of plants to humans and animals to regenerate as well as sustain. This system is very sustainable when used correctly, however it is almost impossible to perform on a commercial scale.

Aquaculture is a combination of hydroponics and aquaponics. It uses the relationship of fish and plants to provide for each other and in turn both benefit and grow. The feces from the fish provide nutrients for the plants, and while taking up those nutrients the fish's water is cleaned. Typically the only input needed for this system is fish food.

Aquaculture seems to be a great area to research because it produces not only plants but also fish which is a main food source throughout the country. The practice uses very little inputs (expensive fertilizers) and does not require soil, both of which are limiting factors throughout the country. Currently the only plants being tested in this system are herbs and the only fish used is Tilapia.

The future design chosen will stem off of this research but will have more proficient plants and different types of fish. The fish ponds will be located under ground on the slope of a hill in large tanks to keep the water cool. The growing beds for the

plants will be located adjacent to the tanks in a greenhouse that is set lower in elevation to allow the natural flow of water from the tanks to the growing beds, reducing the amount of energy needed.

The complex will be in connection with the existing institute and will use energy from their solar panels. Additional solar panels may need to be installed to accommodate the new complex. A large 1/2hp commercial sump pump will be needed to force used water from the growing beds back up to the fish tanks (10 at 1000 gallons). At 32 sq ft a tank, the under ground housing unit will need to be at least 400 sq ft to house all ten tanks. In order to research this method on a commercial scale the greenhouse will need to be large. With a 20,000 sq ft greenhouse, broken into two large rooms by a single pane glass dividing wall, there will be enough room to grow the tomatoes and peppers being analyzed.

The greenhouse will have a single pane glass roof. The use of glass is necessary in this region because the high amount of radiation will decompose the traditionally used polyethylene glazing material. The single pane will also allow for more heat loss which in this region will be necessary in a greenhouse. Large side vents will be needed to allow as much air flow as necessary to keep the plants at a proper temperature. The cool water will help considerably but added air flow will still be needed. Also having the facility positioned on the northside of the hill will reduce the amount of sunlight.

A few experiments that will be tested in this greenhouse setup will be more structured around the plants not the fish. The single fish oriented experiment will be using a few different species of fish such as catfish, tilapia, and mollusks, to see which

produce the highest level of nutrients for the plants, while looking at the amount of input needed for their growth. The majority of the experiments will be done in the greenhouse.

The growth rate of the crops will be the number one piece of data collected. A high growth rate is essential in commercial production and if aquaculture cannot provide a high growth rate than other methods of production will need to be considered. The size and taste of the fruits will also be highly considered throughout the experiment. If this method doesn't allow for large, healthy looking fruit that tastes the same as conventional methods then it will not sell and will be worthless.

To compose this data a few experiments will be carried out over a four year period. The necessity to find a sustainable production practice does not allow for much time. In the first year, the feces from the three different species of fish will be added to separate beds of the crops to evaluate if one promotes better growth. The two crops will be separated into their own greenhouse. For the second year, after revising the data collected through year one the fish that promoted the best growth will be used strictly. Several different cultivars of the two crops will be introduced and tested to see which excel in this method. Year three will introduce the combination of the crops into the same greenhouse to test for certain pathogenic problems. One genus in a greenhouse could promote disease that could be fixed simply by adding another genus to the greenhouse. Finally year four will test the total amount of crop that can be grown in this setting. The use of several different planting widths will determine how closely the crops can be together and still produce the quantity and quality of fruit necessary.

If there isn't a fish species that clearly excels in promoting crop growth than Tilapia will be used because of it requiring very low input and it has a greater selling

ability. The cultivars will all be chosen from those that grow exceptional in the Bahamas already to provide for a better comparison of the fruit.

Since tomatoes and peppers have the same amount of average days until harvest (avg. 65 days) the production time can be the same for both greenhouses. This is incredibly important when considering pathogens. Having different ages of crops in the greenhouse can promote higher levels of disease. If an older plant is infected and a new crop is introduced to the greenhouse the young plants will be highly susceptible and the infected plant could wipe out the entire young crop. Crops become less susceptible with age, so this is an ideal selling point. Because of the region production can be executed year round inside the greenhouse. A production schedule is hard to make up for these two crops because each plant will be ready to harvest at slightly different times. Hand harvesting will be done as the fruit becomes ripe.

Sanitation of the beds is a great way to keep pathogens out of the greenhouse. In a commercial setting it isn't be very economical to completely clear out the greenhouse and have to start the crops over, but would need to be done if a breakout occurred and is a sure-fire way of eliminating the pathogen. If disease is only seen in one of the beds, that bed can be cleared out and sanitized but the risk of the pathogen being in the other plants can still exist.

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