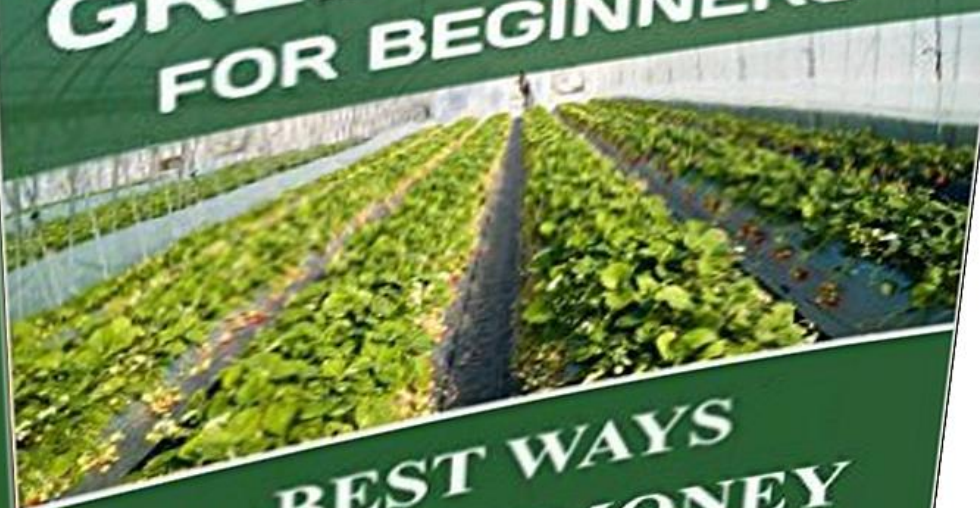


Small BUSINESS

Profitable Farming In Kenya



GREENHOUSES FOR BEGINNERS



**BEST WAYS
TO MAKE MONEY
FROM YOUR
GREENHOUSE**

Timothy Angwenyi

Greenhouse For Beginners

Best Ways To Make Money From Your GreenHouse

By: Timothy Angwenyi



With agribusiness becoming one of the major investment opportunities for Kenyans, the demand for greenhouses has risen significantly with many people looking to start greenhouse farming in Kenya. More and more people are investing into this business with the hope of making good returns from it.

To manage the challenges of rainfall, degraded land and decreasing land sizes, I urge farmers to go for greenhouse. A greenhouse, a protected space for growing vegetables, plants and crops, is a prime real estate, so one should choose crops to maximize profits and produce crops that don't do well outside.

One advantage of using a greenhouse is that farmers can grow vegetables and crops at any time of the year – when they can't be grown outdoors. This is because it allows them to extend the seasons and produce a wide range of vegetables.

Greenhouse cultivation, enables farmers to grow their crops under optimized and standardized conditions, which protects the plants from pests and bad weather.

Farmers using greenhouse to grow out-of-season crops such as tomatoes, lettuce, basil, and other vegetables where they can command high prices in the market.

In choosing what type of plants to grow for profit, a farmer must figure out the right combination of profitable plant varieties, sizes, and quantities.

A Greenhouse is essentially a controlled environment limiting the devastating effects of insect pests and diseases that ravage vegetables including tomatoes. It is not rain-fed but brain-fed, as it comes complete with a customized drip irrigation system. With little amount of land space and water, you are sure to get a yield far higher than your traditional open field production.

I wrote this eBook to ensure that farming is made attractive even among our youths, through modern technology with the greenhouse farming concept and access to quality inputs and technical support.

Copyright

Written By: Timothy Angwenyi morebu (0714723004)

Agribusiness Writer

Copyright © 2016 by Timohbright.

All rights reserved.

First Edition: May 2016

Profitable Farming Guide Series

This guide is geared towards providing exact and reliable information in regards to the topic and issue covered. In no way is it legal to reproduce, duplicate, or transmit any part of this document in either electronic means or in printed format. Recording of this publication is strictly prohibited and any storage of this document is not allowed unless with written permission from the writer. All rights reserved.

About The Writer

Hello! My name is Timothy Angwenyi Morebu. My phone number is **0714723004**. My email also is timohangwenyi@gmail.com. I am a Agribusiness writer, Agri-tourist & an Entrepreneur. Am currently writing *guides on various ways of earning a living in Kenya through Profitable Farming (Entrepreneurship)*, whereby i educate Kenyans on business ideas to venture in Agriculture sector.



Helping people start Agribusinesses and achieve the income they desire has become a huge part of my life. Being able to share the knowledge I have gained through visiting people's farms and attending Agriculture seminars and exhibitions has become extremely important to me.

I consider my readers my friends. I am always so appreciative that they take their time out to read my eBook guides and to learn about Agribusiness ideas from me. Once you have finished reading this guide, I have no doubt that you will have learned a great deal about Greenhouse Farming in Kenya.

Copyright © 2016 Timohbright

Acknowledgements

First and foremost, I would like to thank my wife Angela for standing beside me throughout my research, visiting greenhouses in Kenya and writing this ebook. She has been my inspiration and motivation for continuing to improve my knowledge and move my agribusiness skills forward. She is my rock, and I dedicate this ebook to her.

I also thank my wonderful children: Katie & Kim, for always making me smile and for understanding on those weekend mornings when I was writing this ebook instead of playing games. I hope that one day they can read this ebook and understand why I spent so much time in front of my computer.

I'd like to thank my parents and grandparents for allowing me to follow my agribusiness ambitions throughout my childhood. My family, including my in-laws, have always supported me throughout my agribusiness career and authoring this ebook and I really appreciate it. I look forward to discussing this ebook with my family at future gatherings as I'm sure they will all read it soon.

My co-agribusiness friends, especially Roger Miseti, Smith Kimathi, and Matt Arena, who showed me the ropes in IT and Agri-touring to people's farms. I thank each of my friends for devoting their time and effort towards this ebook; I think that it will be a great asset to the Kenyan community!

Thanks for everything, I look forward to writing more and more agribusiness ebooks!

Table of Content

Chapter 1: Getting Started	Pg. 8
Chapter 2: Greenhouse Business Plan	Pg. 20
Chapter 3: Cost of Building a Greenhouse	Pg. 41
Chapter 4: Selecting Your Greenhouse Location	Pg. 58
Chapter 5: Construction of Your Greenhouse	Pg. 67
Chapter 6: What to Grow in a Greenhouse	Pg. 103
Chapter 7: Best greenhouse management skills and crop protection	Pg. 130
Chapter 8: Marketing Your Greenhouse Produce	Pg. 192
Chapter 9: Greenhouse Farming Tips	Pg. 198
Chapter 10: Success stories of Kenyan Farmers owning Greenhouses	Pg. 207
Conclusion	Pg. 226

Chapter 1

Getting Started



While the population is ever growing, land size remains fixed. Thus there is increasing pressure on land especially for agricultural or food production. In Kenya, about 80% of the population depends on agriculture for both food and employment.

One of the ways to get around this challenge of increasing shortage of land is to embrace new technologies and modes of farming that require small space but produce high yields. The Ministry of Agriculture and private stakeholders are promoting Greenhouse farming as one of the strategies to counter land shortage and increase food production.

A greenhouse is a structure in which crops are grown. These structures range from small sheds to industrial-size structures. Greenhouse farming is the type of farming in which crops are grown in built structure with different types of covering materials such as glass or plastic roofing and walls. There are two types of greenhouse farming. One is growing crops directly in the soil on open space where the plants are susceptible to soil-borne diseases.

The second type of greenhouse farming is growing crops in artificial enclosed systems such as cocopeat, vermiculite etc which are disease free and require controlled fertilizer application through irrigation.

The good news for farmers in Kenya is that the greenhouse technology can increase your profits highly. There are many Kenyan Greenhouse construction and consultancy companies helping Kenyan farmers to set up greenhouses.

The beauty with a greenhouse is that the structure can last at least 15 years. In one acre of land, one can have close to 8 greenhouses especially those who would like to go into large scale commercial farming.

Greenhouse farming is clean because it doesn't require using the ordinary hoe and touching the soil. A farmer is provided with protective gear.

Crops in a greenhouse are less contaminated with chemicals because the latter are mixed with water in the tank that is passed onto the plants using the drip irrigation method. Drip irrigation allows water to drop only on the basement of the plant thus minimizing wastage of water and eliminating weeds.

A farmer doesn't spend on pesticides because the greenhouse is protected to prevent contact with pests and disease.

It saves water because a farmer only requires 1000 litres to water a greenhouse of 500sqm per day. Green house farming can also be used as a security to get a loan from a bank or financial institution.

How Does a Greenhouse Work?



How does a greenhouse work? Once you understand how a greenhouse works, you can better utilize this tool to help you get the most out of your gardening. From simplistic to complex, greenhouses are effective at promoting plant growth and fruit production.

How Does a Greenhouse Work Scientifically

The greenhouse works by collecting light and converting it to heat. That is a simplistic view of how a greenhouse works. In addition to capturing light, the greenhouse also stores thermal energy and releases that energy properly. It can help moderate temperature and produce a controlled environment for plants to grow and thrive in. Further, a greenhouse offers protection from wind, rain, snow and other weather elements while also keeping your fruits from invading pests and animals.

Solar Collection

The main task of a greenhouse is to collect solar energy. The greenhouse captures light through its walls and converts it to heat. The effect is similar to that of a vehicle with the windows up. It takes only a few minutes for light coming in a window to warm up the vehicle to a temperature significantly higher than the outside temperature. Greenhouses work the same

way. The darker material within the greenhouse helps to store heat, keeping the surrounding air warmer.

The greenhouse is a closed-in environment, which means there are no breezes to push the heat away. The structure is often made of glass, or glass-like material that helps to attract the sun's rays. Without a breeze, the air within the greenhouse heats up quickly and remains warm. This creates the ideal area for plants to grow.

Releasing Thermal Energy

As the greenhouse draws in and collects sunlight, it warms the air within. This occurs naturally. The process is releasing thermal energy. The matter within the greenhouse, such as the soil and water, will absorb the heat drawn in. Even when the sun goes down, the warmth in the soil and water continue to protect the plants because these materials release the warmth slowly.

Another important factor in protecting your plants is the way greenhouses regulate temperature. The thermal mass within the greenhouse helps to keep the temperatures moderate. If your greenhouse is larger and has thermal mass within it, such as the iron found in soil, it will heat up slowly and will cool down slowly. Rather than high heat in the daytime and cold temperatures at night, the thermal mass within the greenhouse regulates the temperature evenly throughout the day and night. This provides a better atmosphere for plants to grow.

Protection from the Elements

Another way in which greenhouses work is by providing protection from the elements. In this manner, greenhouses function much as a house does for humans. Protection from the elements is critical, especially when you are gardening in the fall or winter months. Consider some of the ways a greenhouse protects.

- ❖ The greenhouse prevents strong winds from pulling up roots or blowing seeds.
- ❖ It allows you to control how much water your plants receive. Rain and hail are unable to get in.

- ❖ Pests, including vegetable eating pests, are kept out. You do not have to spray harsh chemicals on your plants. You control the types of insects or other pests allowed into the garden. It may not be possible to keep all pests out long term, but you will minimize the number.
- ❖ A greenhouse keeps excess heat and cold from affecting plants. When the temperature gets too high, the fogging or misting systems within some greenhouses can help to cool down the temperature. Other systems heat up the greenhouse when there is limited sunlight.

The ability to protect plants from any of these elements is critical to helping those plants to grow successfully. Greenhouses adjust the weather conditions to allow for better growth.

When you ask, "How does a greenhouse work" keep in mind there are numerous types of greenhouses. Some are, very simply, structures with polythene walls. Others have complex heating and cooling systems within them to help control temperatures. When selecting a type of greenhouse to use, focus on your budget and your needs to control the climate.

How greenhouse farmer beat setup earns millions



Alice Chuaga has earned tidy profits from growing crops in greenhouses. Listening to Alice Chuaga speak about her farms worth millions of shillings, one would be forgiven to think that she is an agronomist or a greenhouse technology expert.

But the greenhouse farmer from Nyeri says her passion and use of cheap materials is what has driven her to attain this kind of success.

Chuaga says she opted for improvised greenhouses with lower maintenance costs, that uses water more efficiently and one that can be easily moved to cut on setup costs.

An average greenhouse unit of eight metres by 30 meters costs about Sh.200,000. This cost includes laying pipes for drip irrigation. Chuaga says farmers who are unable to afford the steel structures can build their own greenhouses using timber poles at a much lower cost.

“I set aside Sh.16,000 to personally construct and install the pipes for drip irrigation for a single greenhouse unit and now I own three,” she says.

“I have two greenhouses on my a quarter plot in Nyeri where I plant tomatoes and capsicums,” Chuaga says, adding that she has already erected the third one in her kitchen garden to grow passion fruits.

“My first Anna F1 tomatoes harvest from the improvised greenhouse in my kitchen garden was quite notable. I harvested 19,000 kilogrammes (kg) of tomatoes which I sold at Sh.110 per kg.”

The tomatoes mature after 75 days and after each harvest she says she collects between Sh.209,000 to Sh.450,000.

Although prices fluctuate because of supply and demand, she says during low seasons she harvests 3,016 kgs of tomatoes with a kilo going for as low as Sh.60 but on the higher side a kg would go for Sh.110.

“I sell the tomatoes to hotels in town, individuals and some to my neighbours,” she says.

The mother of three also grows capsicums. She says any vegetable can be grown in greenhouses and capsicum has fetched her good profits.

“I got the idea from my friends in Nairobi. The first time, I managed to harvest 20kgs of red and yellow capsicums. Recently, I earned Sh.160,000 from selling capsicums to ABC Place and Zuchiri hotel in Nairobi and Mombasa.”

To cushion her from tough times especially during low production or market glut, she says has also planted sukuma wiki among other vegetables in her backyard and does not lack Sh.1,400 from weekly sales.

Besides greenhouse farming, Chuaga also keeps 180 indigenous chicken where a mature cock goes for Sh.1,200 and a hen Sh.600. The once impoverished farmer, Ms Chuaga is now reaping the fruits of her labour.

She now counts the millions of shillings that she has earned from growing tomatoes, capsicums, kales, broccoli, cauliflower and onions and from sale of chicken and eggs.

“I love to venture into other types of crops as a way of earning additional income ,” she says.

The success of her improvised greenhouses has attracted many people and has gained her slots in international trade fairs.

“I get quite a number of referrals. Hence, I have constructed 12 greenhouse units for other people. They always thank me,” says Chuaga.

Despite the high returns, she doesn't rest easy and has recently acquired a 115 acres land in Loitoktok where she has planted tomatoes on an open field as she focuses on large scale farming, although she prefers greenhouse farming.

“Greenhouse farming is the best as it prevents crops from pests. It uses little or no chemicals despite people’s mentality that alot of chemicals are used in this form of farming,” she says.

Greenhouse farming has rewards, she says.

“These include higher and more consistent production per acre, which translates into more profits, protection from harsh weather conditions like frost and wind, limited exposure to damaging pests, natural sunlight and ventilation, longer growing seasons, and more economical water usage, especially in dry areas,” says Ms Chuaga.

Being a Millionaire Only Requires a Successful Greenhouse!

Using the word **only** to describe a greenhouse is a gross understatement. Green houses are like infants; you’ve got to watch them all the time. Just yesterday I was in a meeting with a lady who said that her green house is in ICU. Her tomato crop had been attacked by blossom-end rot. The crop was drying so fast that she was panicking. Huge losses were staring her in the face.

In greenhouse business, a host of diseases, pathogens and insects can make you uproot your entire crop if either attacks. Nonetheless, I find the word **only** a befitting qualifier for a greenhouse when you are looking at Ksh. 10 Million return on investment in two years. Hence, you **only** need a greenhouse to become a millionaire.

Does having 10 million in the bank make you a millionaire? Well, we can talk about who is a millionaire another day. Today we talk about Linda Atambitsa, a 32 year-old microbiologist whose quest for a satisfying career landed her on a path to millions.

Linda’s motivation to get into agribusiness



Linda was until June 2013 a Quality Assurance Supervisor at a leading dairy processing company. However, she felt that her energy was not being fully utilized at the company and decided to quit a well-paying job to get on track with what she trained for at the university; medical microbiology.

“I got tired of writing reports and quit a job that most of my peers envied. I was earning over Ksh. 100,000 but I needed to get out. I trained to be a microbiologist and I want to practice it,” Linda explains.

Never quit a job unless you have a plan



Getting into a career in her area of expertise would take a bit of time and Linda needed a source of income as she sought the career of her dreams. She started plotting her exit plan from her job in December 2012.

Linda knew that she needed change in her career and she had to prepare for the ups and downs of that change. Before quitting her job she carefully analyzed investment ideas and finally settled for greenhouse farming. This was after interacting with John Maingi, the Director of Foods Africa Enterprise. Linda did a plant projection analysis on greenhouses and she loved the bottom line. In business, it is always about the profits.

Greenhouses are capital intensive

Despite the obvious profits from greenhouse farming, these paper houses are damn expensive to put up. Linda used up most of her savings to put up one green house on a quarter acre of land. She did not have land that was easily accessible to her. Farming is hands on and Linda knew that from the onset. She needed to lease land that she could easily access at any time. Fortunately, she found a piece of land in Ruiru. It cost her Ksh.600,000 to lease land, put up the greenhouse structure, get seedlings and fertilizer from Foods Africa Enterprises. This was a fair deal considering that Linda used cheap and easily material for the greenhouse.



You can reduce the cost of constructing a greenhouse using cheaper materials

Yellow and Red capsicums are Linda's gold mine



A variety of high value crops can be grown in greenhouses: tomatoes, garlic, beetroot, cucumbers, chillies, eggplant and capsicums among others. Depending on the farmer's focus and passion, each crop has its own pros and cons.

Linda found capsicums to be the best for her greenhouse project. They are ornamental vegetables that go for Kshs.350 per kg in supermarkets and the export market is insatiable. Linda has a combination of yellow and red capsicums in her greenhouse. She never has to worry about market glut or fluctuating market prices. She has a ready market thanks to her partnership with Foods Africa Enterprises. The company buys all her produce once it's ready.

Agriculture demands patience

In April 2013, Linda's green house project almost came to a halt. She had depleted her savings and she was about to give up. She was still in the construction stage of the greenhouse. Luckily, she willed herself back on track and sought alternative ways to make a cheap greenhouse. Today, her huge greenhouse is the marvel of many.

Challenges are part of the business in commercial agriculture. When I met Linda for this interview, she was diagnosing a disease on her crop that was making leaves fold and flowers to fall off. The loss of a flower on a capsicum plant is the loss of a fruit. Linda tells me that she is lucky that her background in science helps her detect any changes on her crop. She is doubly lucky

to have Foods Africa offer consultancy services for her farm. That is how her crop is still thriving despite the minor threats of diseases.



Linda's advice

The sweetest moments in agribusiness are harvest time. Linda is currently pocketing an average of Ksh.30,000 per week from her harvest. She planted her capsicum seedlings on June and it is already harvest time!

Linda however advises that young people getting into agribusiness should cultivate patience. Agribusiness is not an economic aspirin for financial troubles. Just like any investment, it requires planning, adequate preparation and it is very risky.

Chapter 2

Greenhouse Farming Business Plan



Are you about starting a greenhouse farming business? If YES, here is a complete sample greenhouse farming business plan & feasibility study you can use.

Okay, so i have considered all the requirements for starting a greenhouse farming business. I also took it further by analyzing and drafting a sample greenhouse farming marketing plan backed up by actionable guerrilla marketing ideas for greenhouse farming businesses. So let's proceed to the business planning section.

There are several business opportunities available in the agricultural industry and one good thing about the industry is that there is market for all the produce from the industry. Over the years, researchers and scientist have been researching on ways to improve crop cultivation especially in areas where the soil composition and climatic condition does not support the growth of certain crops (cash crops, food crops etc). So also engineers have been improving on their invention as regards mechanized (commercial) farming.

Why Start a Greenhouse Farm?

The agricultural industry of which greenhouse farming business is a subset of is no doubt amongst the leading industries in most countries of the world. It is the industry that produces food for the populace and raw materials for industries. Because of the significant role the agriculture sector plays, the government of most countries ensures that they go all the way to subsidize seedlings, fertilizers, and farming implements and machinery for farmers and also encourage entrepreneurs to go into greenhouse commercial farming business.

If you are willing to start this business, you will need to write out the plan upon which you want to build this business. You will need to write about the marketing strategies that you want to adopt, the location of business, the type of legal entity that you want to use amongst many other things.

Here below is a sample greenhouse commercial farming business plan that i wrote from my imagination and i hope it can help you as you write your own greenhouse business plan.

A Sample Greenhouse Farming Business Plan

Business Overview

Greenhouse commercial farming is rapidly gaining entrance in our world today. Greenhouse farming gives room for greater control over the growing environment of various crops. Dependent upon the technicality and specification of a greenhouse design, some of the important factors which may be controlled include temperature, levels of light and shade, irrigation, fertilizer application, and atmospheric humidity et al.

Basically, Greenhouses are used to overcome shortcomings in the growing qualities of a piece of land, such as a short growing season or poor light levels. In essence, they are designed to improve food production in marginal environments.

This is so because Greenhouses enable certain crops to be grown all through the year irrespective of the climatic conditions. Greenhouses are increasingly becoming an important factor in the food supply chain of high-latitude countries.

A greenhouse (also is also known as a glasshouse, or a hothouse as the case may be) is a structure with walls and roof made essentially of transparent material, such as glass, in which plants requiring regulated climatic conditions are grown. These structures vary in size from small sheds to industrial-sized buildings used for commercial farming.

Generally, Greenhouses are often used for cultivating crops such as flowers, vegetables, fruits, and transplants etc. Special greenhouse varieties of certain crops, such as tomatoes, are generally used in tomatoes paste companies and for commercial production.

Many commercial glass/polythene greenhouses or hothouses are high tech commercial production facilities for vegetables or flowers. Usually, the glass greenhouses are filled with equipment such as screening installations, heating, cooling, lighting, and also may be controlled by a computer to enhance conditions for plants to grow effectively.

The Greenhouse Commercial Farming industry is indeed a fast growing industry and pretty much active.

One thing is certain about greenhouse commercial farming, if you are able to conduct your market research and feasibility studies, you are more likely not going to struggle to sell your farm produce because there are always food processing companies and consumers out there who are ready to buy from you.

Greenhouse Farming Business Plan – Executive Summary

Eddie Greenhouse – Farms, LLC is a registered and licensed agro – allied company that will be based in the outskirts of Kisii County – Nyanza. We have done our detailed market research and feasibility studies and we were able to secure a 25 hectares of land to start our

greenhouse commercial farms. We will construct a structure with walls and roof made essentially of transparent material, such as glass, in which plants requiring regulated climatic conditions are grown.

At Eddie Greenhouse – Farms, LLC we will be involved in the cultivation of crops such as; cucumbers, tomatoes, capsicum, snow peas, Chinese cabbage, french beans, strawberries, melons, onions, sweet potato and eggplant as well as the choys that are used for stir fries. We will also be involved in cultivating flowers and agriculture related transplants.

In the nearest future, hopefully within the first five years of officially running Eddie Greenhouse – Farms, LLC, we will start our food processing and packaging plant and also start exporting our agriculture produce to other parts of the world.

This is why aside from the fact that we've secured the required farming land and most of the farming equipment and machines; we have also hired some key employees who are currently undergoing training so as to be able to fit into the ideal picture of the 21st century greenhouse commercial farming business workforce that we want to build.

We are in the greenhouse commercial farming business because we want to leverage on the vast opportunities available in the Agriculture industry, to contribute our quota in growing the Kenyan economy, in national food production, raw materials production for industries, to export agriculture produce from Kenya to other countries and over and above to make profit.

Eddie Greenhouse – Farms, LLC is well positioned to become one of the leading greenhouse commercial farms in Kenya, which is why we have been able to source for the best hands and machines to run the business with. We have put process and strategies in place that will help us employ best practices when it comes to greenhouse commercial farming processes and food processing and packaging as required by the regulating bodies in Kenya.

Eddie Greenhouse – Farms, LLC is a private registered agro – allied company that is owned by Dr. Eddie Madowo and family. The company will be fully and single handedly managed by the owner – Dr. Eddie Madowo and his immediate family members at least for a

period of time. Before starting Eddie Greenhouse – Farms, LLC, Dr. Eddie Madowo was the Head of a renowned Agriculture Research Institute in Kenya and he worked in the industry for well over 15 years before resigning to start his own greenhouse commercial farming business. Dr. Eddie Madowo is a known agriculture scientists in Kenya.

Our Services

Eddie Greenhouse – Farms, LLC is an agro – allied company that will be involved in cultivating various crops via greenhouse farming model for both the Kenyan market and the global market. We are in business to produce both vegetable, and fruits in commercial quantities. We will also ensure that we operate a standard food processing and packaging plant as part of our complimentary business.

These are the areas we will concentrate on in our greenhouse commercial farms. If need arises we will definitely add more agriculture produce to our list;

- ❖ Cultivation of crops such as; cucumbers, tomatoes, capsicum, snow peas, Chinese cabbage, french beans, strawberries, melons, onions, sweet potato and eggplant as well as the choys that are used for stir fries. We will also be involved in cultivating flowers and agriculture related transplants.
- ❖ Plant transplant services
- ❖ Vegetable and fruit processing and packaging
- ❖ Greenhouse construction, consultancy and advisory services

Our Vision Statement

Our Vision is to become one of the leading greenhouse commercial farm brands not just in Kenya but also on the global stage.

Our Mission Statement

Our mission statement as a greenhouse commercial farm is to go into full – time cultivation of vegetables, and fruits that will not only be consumed in Kenya, but also exported to other parts of the world. We want our processed fruits and vegetable to flood the nooks and crannies of Kenya and other countries of the world.

Our Business Structure

Eddie Greenhouse – Farms, LLC is a family owned and managed commercial greenhouse farm that is into the cultivation of vegetables and fruits.

At Eddie Greenhouse – Farms, LLC, we will ensure that we hire people that are qualified, hardworking, creative, customer centric and are ready to work to help us build a prosperous business that will benefit all the stakeholders (the owners, workforce, and customers).

As a matter of fact, profit-sharing arrangement will be made available to all our senior management staff and it will be based on their performance for a period of five years or more as agreed by the board of trustees of the company. In view of the above, we have decided to hire qualified and competent hands to occupy the following positions;

- ❖ Chief Operating Officer
- ❖ General Farm Manager
- ❖ Administrator / Accountant
- ❖ Crop (Vegetable and Fruits) Cultivation Manager / Supervisor
- ❖ Vegetable and Fruits Processing and Packaging Plant Manager / Supervisor
- ❖ Sales and Marketing Executive
- ❖ Front Desk Officer

Roles and Responsibilities

Chief Executive Officer – CEO:

- ❖ Increases management's effectiveness by recruiting, selecting, orienting, training, coaching, counseling, and disciplining managers; communicating values, strategies, and objectives; assigning accountabilities; planning, monitoring, and appraising job results; developing incentives; developing a climate for offering information and opinions; providing educational opportunities.
- ❖ Responsible for providing direction for the business
- ❖ Creates, communicates, and implements the organization's vision, mission, and overall direction – i.e. leading the development and implementation of the overall organization's strategy.
- ❖ Responsible for signing checks and documents on behalf of the company
- ❖ Evaluates the success of the organization

General Farm Manager

- ❖ Responsible for the planning, management and coordinating all farm activities across the various sections on behalf of the organization
- ❖ Supervise other section manager
- ❖ Ensure compliance during project executions (especially in the construction of greenhouse and hothouse et al)
- ❖ Providing advice on the management of farming activities across all section
- ❖ Responsible for carrying out risk assessment
- ❖ Using IT systems and software to keep track of people and progress of the growth of crops, fishes, birds and animals
- ❖ Responsible for overseeing the accounting, costing and sale of farm produce after harvest
- ❖ Represent the organization's interest at various stakeholders meetings
- ❖ Ensures that farming goals desired result are achieved, the most efficient resources (manpower, equipment, tools and chemicals et al) are utilized and different interests involved are satisfied. Responsible for preparing financial reports, budgets, and financial statements for the organization
- ❖ Responsible for overseeing the smooth running of HR and administrative tasks for the organization
- ❖ Handles all financial transactions for the company
- ❖ Defines job positions for recruitment and managing interviewing process
- ❖ Carries out staff induction for new team members
- ❖ Responsible for training, evaluation and assessment of employees

- ❖ Oversees the smooth running of the daily farming activities across the various farming sections.

Administrator / Accountant

- ❖ Responsible for overseeing the smooth running of HR and administrative tasks for the organization
- ❖ Defines job positions for recruitment and managing interviewing process
- ❖ Carries out staff induction for new team members
- ❖ Responsible for training, evaluation and assessment of employees
- ❖ Responsible for preparing financial reports, budgets, and financial statements for the organization
- ❖ Responsible for financial forecasting and risks analysis.
- ❖ Responsible for developing and managing financial systems and policies
- ❖ Responsible for administering payrolls
- ❖ Ensures compliance with taxation legislation
- ❖ Handles all financial transactions for the company
- ❖ Serves as internal auditor for the company

Crop (Vegetable and fruits) Cultivation Manager / Supervisor

- ❖ Responsible for the cultivation of crops such as; cucumbers, tomatoes, capsicum, snow peas, Chinese cabbage, french beans, strawberries, melons, onions, sweet potato and eggplant as well as the choys that are used for stir fries. We will also be involved in cultivating flowers and agriculture related transplants.
- ❖ Handles plant transplant services
- ❖ Supervises other workers within the department
- ❖ Works closely with the General Manager to achieve the organization's goals and objectives

Vegetable and Fruits Processing and Packaging Plant Manager / Supervisor

- ❖ Responsible for managing the fruits and vegetable processing and packaging plant section of the business

- ❖ Supervises other workers within the department
- ❖ Work closely with the General Manager to achieve the organization's goals and objectives

Sales and Marketing Officer

- ❖ Identify, prioritize, and reach out to new markets for our agriculture produce, processed food, new partners, and business opportunities within the agro – allied industry
- ❖ Develops, executes and evaluates new plans for expanding increase sales of all our agriculture produce and processed foods
- ❖ Documents all customer contact and information.
- ❖ Represents the company in strategic meetings
- ❖ Helps to increase sales and growth for the company

Front Desk / Customer Service Officer

- ❖ Welcomes clients and visitors by greeting them in person or on the telephone; answering or directing inquiries.
- ❖ Ensures that all contacts with clients (e-mail, walk-In center, SMS or phone) provides the client with a personalized customer service experience of the highest level
- ❖ Through interaction with clients on the phone, uses every opportunity to build client's interest in the company's farm produce
- ❖ Manages administrative duties assigned by the HR manager in an effective and timely manner
- ❖ Consistently stays abreast of any new information on the organization's' products, promotional campaigns etc. to ensure accurate and helpful information is supplied to potential clients when they make enquiries

Greenhouse Farming Business Plan – SWOT Analysis

Eddie Greenhouse – Farms, LLC do not intend to launch out with trial and error hence the need to conduct a proper SWOT analysis. We know that if we get it right from the onset, we would have succeeded in creating the foundation that will help us build a standard commercial

greenhouse farm that will favorably compete with leading commercial greenhouse farms in Kenya and in the rest part of the world.

As a world – class greenhouse farms, we look forward to maximizing our strength and opportunities and also to work around our strengths, weaknesses and threats. Here is a summary from the result of the SWOT analysis that was conducted on behalf of Eddie Greenhouse – Farms, LLC;

1. Strength:

Our strength as a greenhouse farm company is the fact that we have healthy relationships with loads of major players (agricultural merchants) in the agriculture industry; both suppliers and buyers within and outside Kenya.

We have some of the latest greenhouse farming machines; tools and equipment that will help us cultivate crops in commercial quantities with less stress. Aside from our relationship (network) and equipment, we can confidently boast that we have some the most experienced hands in the greenhouse commercial farming line of business.

2. Weakness:

Our weakness could be that we are a new commercial greenhouse farm in Kenya; it might take some time for our organization to break into the market and gain acceptance especially from international markets in the already saturated and highly competitive commercial farming industry; that is perhaps our major weakness. Another weakness is that we may not have the required cash to promote our business the way we would want to.

3. Opportunities:

The opportunities that are available to us cannot be quantified, we know that everybody on planet earth eat farm produce. We are ready to take advantage of any opportunity that is available in the industry.

4. Threat:

Just like any other business, one of the major threats that we are likely going to face is economic downturn. It is a fact that economic downturn affects purchasing / spending power. Another threat that may likely confront us is the arrival of a new commercial green farm in same location where our target market exist and who may want to adopt same business model like us.

Greenhouse Farming Business Plan – MARKET ANALYSIS

Market Trends

If you are conversant with rising technology and scientific development in the agriculture industry, you will quite agree that greenhouse commercial farming is at the front burner. Greenhouse commercial farming is rapidly gaining entrance in our world today. Greenhouse farming gives room for greater control over the growing environment of various crops.

Dependent upon the technicality and specification of a greenhouse design, some of the important factors which may be controlled include temperature, levels of light and shade, irrigation, fertilizer application, and atmospheric humidity etc.

Basically, Greenhouses are used to overcome shortcomings in the growing qualities of a piece of land, such as a short growing season or poor light levels. In essence, they are designed to improve food production in marginal environments.

This is so because Greenhouses enable certain crops to be grown all through the year irrespective of the climatic conditions. Greenhouses are increasingly becoming an important factor in the food supply chain of high-latitude countries.

Our Target Market

Naturally, the target market of those who are the end consumer of greenhouse commercial farm produce and also those who benefits from the business value chain of the agriculture industry is all encompassing; it is far – reaching. Every household consumes produce from farms be it vegetables, and fruits etc. In essence a commercial greenhouse farmer should be able to sell his or her farm produce to as many people as possible.

We will ensure that we position our business to attract consumers of agriculture produce not just in Kenya alone but also other parts of the world which is why we will be exporting some of our farm produce either in raw form or processed form to other countries of the world.

Our Competitive Advantage

It is easier to find entrepreneur flocking towards an industry that is known to generate consistent income which is why there are more commercial farmers in the Kenya and of course in most parts of the world.

As a matter of fact, entrepreneurs are encouraged by the government to embrace commercial farming. This is so because part of the success of any nation is her ability to cultivate her own food and also export food to other nations of the world.

Eddie Greenhouse – Farms, LLC is fully aware that there are competitions when it comes to selling greenhouse commercial farm produce all over the globe, which is why we decided to carry out thorough research so as to know how to take advantage of the available market in Kenya and in other parts of the world.

We have done our homework and we have been able to highlight some factors that will give us competitive advantage in the marketplace; some of the factors are effective and reliable farming processes that can help us sell our produce at competitive prices, good network and excellent relationship management.

Our competitive advantage lies in the power of our team; our workforce. We have a team of hardworking and highly proficient farmers, a team with excellent qualifications and experience in various niche areas in the agriculture industry. Aside from the synergy that exists in our carefully selected team members, we have some of the latest and efficient greenhouse farm machines and equipment and we will be guided by best practices in the industry.

Another competitive advantage that we are bringing to the industry is the fact that we have designed our business in such a way that we will operate an all – round standard commercial greenhouse farms that will be involved in diverse areas such as crop cultivation, plant transplant services and food processing and packaging plant. With this, we will be able to take advantage of all the available opportunities within the industry.

Lastly, all our employees will be well taken care of, and their welfare package will be among the best within our category (start – ups commercial greenhouse farms in Kenya) in the industry. It will enable them to be more than willing to build the business with us and help deliver our set goals and achieve all our business aims and objectives.

Greenhouse Farming Business Plan – SALES AND MARKETING STRATEGY

We are quite aware that the reason why some commercial greenhouse farms hardly make good profits is their inability to sell off their farm produce especially perishable crops as at when due. In view of that, we decided to set up a standard food processing plant to help us maximize profits.

Our sales and marketing team will be recruited based on their vast experience in the commercial farms industry and they will be trained on a regular basis so as to be well equipped to meet their set targets and the overall business goal of Eddie Greenhouse – Farms, LLC.

Our goal is to grow Eddie Greenhouse – Farms, LLC to become one of the leading commercial greenhouse farms in Kenya which is why we have mapped out strategies that will

help us take advantage of the available market and grow to become a major force to reckon with not only in Kisii County but also in other counties in Kenya and the world at large.

Over and above, we have perfected our sale and marketing strategies first by networking with agriculture merchants and companies that rely on raw materials from the agriculture industry who are likely to become our customers. In summary, Eddie Greenhouse – Farms, LLC will adopt the following strategies in marketing our commercial farm produce;

- ❖ Introduce our business by sending introductory letters alongside our brochure to stakeholders in the agriculture industry, companies that rely on the agriculture industry for their raw materials, hotels and restaurants and agriculture produce merchants etc.
- ❖ Advertise our business and agriculture produce in agro – allied and food related magazines and websites
- ❖ List our commercial greenhouse farms on yellow pages ads
- ❖ Attend related agriculture and food expos, seminars, and business fairs etc.
- ❖ Leverage on the internet to promote our business e.g creating our website, posting adverts on Olx.com e.t.c
- ❖ Engage in direct marketing
- ❖ Encourage the use of word of mouth marketing (referrals)

Sources of Income

Eddie Greenhouse – Farms, LLC is in the green commercial farming business for the purpose of maximizing profits hence we have decided to explore all the available opportunities within the industry to achieve our corporate goals and objectives. In essence we are not going to rely only on the sale of our farm produce to generate income for the business.

Below are the sources we intend exploring to generate income for Eddie Greenhouse – Farms, LLC;

- ❖ Sale of crops such as; cucumbers, tomatoes, capsicum, snow peas, Chinese cabbage, french beans, strawberries, melons, onions, sweet potato and eggplant as well as the choys that are used for stir fries. We will also be involved in cultivating flowers and agriculture related transplants.

- ❖ Plant transplant services
- ❖ Vegetable and fruit processing and packaging
- ❖ Greenhouse construction, consultancy and advisory services

Sales Forecast

From the survey conducted, we were able to discover that the sales generated by a Greenhouse commercial farm depends on the size of the farm, and the nature of the commercial farm

We have perfected our sales and marketing strategies and we are set to hit the ground running and we are quite optimistic that we will meet or even surpass our set sales target of generating enough income / profits from the year of operations and build the business from survival to sustainability.

We have been able to critically examine the agriculture industry greenhouse commercial farm business and we have analyzed our chances in the industry and we have been able to come up with the following sales forecast. The sales projection is based on information gathered on the field and some workable assumptions as well with respect to the nature of greenhouse commercial farm that we run.

Below are the projections that we were able to come up with for the first three years of running Eddie Greenhouse – Farms, LLC;

- ❖ **First Year-:** Ksh.20,000,000
- ❖ **Second Year-:** Ksh.50,000,000
- ❖ **Third Year-:** Ksh.80,000,000

N.B: This projection is done based on what is obtainable in the industry and with the assumption that there won't be any major economic meltdown that can impact negatively on household spending, bad weather cum natural disasters (droughts, epidemics), and unfavorable government policies

Our Pricing Strategy

Some of the factors that will help you sell your farm produce at the right price that will guarantee that you make profits is dependent on your strategy while some of the factors are beyond your control. For example, if the climatic condition is unfavorable and if there are natural disasters in the location where you have your commercial farm, then it will directly affect the prices of your farm produce.

Over and above, if you want to get the right pricing for your farm produce, then you should ensure that you choose a good location for a Greenhouse commercial farm, choose a good breed / seeds that will guarantee bountiful harvest, cut the cost of running your farm to the barest minimum and of course try as much as possible to attract buyers to your farm as against taking your farm produce to the market to source for buyers; with this, you would have successfully eliminate the cost of transporting the goods to the market and other logistics.

We are quite aware that one of the easiest means of penetrating the market and acquiring loads of customers for all our agriculture produce is to sell them at competitive prices hence we will do all we can to ensure that the prices of our farm produces are going to be what other commercial farmers would look towards beating.

One thing is certain, the nature of greenhouse commercial farming makes it possible for farmers to place prices for their farm produce based on their discretion without following the benchmark in the industry. The truth is that it is one of the means of avoiding running into loss. The easier you sell off your harvest the better for your business.

Payment Options

The payment policy adopted by Eddie Greenhouse – Farms, LLC is all inclusive because we are quite aware that different customers prefer different payment options as it suits them but at the same time, we will ensure that we abide by the financial rules and regulation of Kenya.

Here are the payment options that Eddie Greenhouse – Farms, LLC will make available to her clients;

- ❖ Payment via bank transfer
- ❖ Payment via Mpesa
- ❖ Payment with cash
- ❖ Payment via online bank transfer
- ❖ Payment via check
- ❖ Payment via bank draft

In view of the above, we have chosen banking platforms that will enable our client make payment for farm produces purchase without any stress on their part.

Greenhouse Farming Business Plan – Publicity and Advertising Strategy

Any business that wants to grow beyond the corner of the street or the city they are operating from must be ready and willing to utilize every available means (both conventional and non – conventional means) to advertise and promote the business. We intend growing our business which is why we have perfected plans to build our brand via every available means.

We know that it is important to create strategies that will help us boost our brand awareness and to create a corporate identity for our greenhouse commercial farm business. Below are the platforms we can leverage on to boost our greenhouse commercial farm brand and to promote and advertise our business;

- ❖ Place adverts on both print (newspapers and magazines) and electronic media platforms
- ❖ Sponsor relevant community based events / programs
- ❖ Leverage on the internet and social media platforms like; Instagram, Facebook , twitter, YouTube, Google + e.t.c to promote our business
- ❖ Install our Bill Boards on strategic locations all around Kisii county and neighbouring counties.
- ❖ Engage in road show from time to time in targeted neighborhoods
- ❖ Distribute our flyers and handbills in target areas

- ❖ Contact corporate organizations and residence in our target areas by calling them up and informing them of Eddie Greenhouse – Farms, LLC and the farm produce we sell
- ❖ List our greenhouse commercial farms in local directories / yellow pages
- ❖ Advertise our greenhouse commercial farms in our official website and employ strategies that will help us pull traffic to the site.
- ❖ Ensure that all our staff members wear our branded shirts and all our vehicles and trucks are well branded with our company logo.

Greenhouse Farming Business Plan – Financial Projections and Costing

When it comes to calculating the cost of starting a greenhouse commercial farm, there are some key factors that should serve as a guide. The most important expenses is the construction of the greenhouse or hothouse as the case may be.

For example, the start – up cost for a fish farm is different from the start – up cost for mechanized crop farming, so also the start – up cost for poultry farming is different from the start – up cost of cattle ranch (dairy farm). As a matter of fact, if you choose to start a mechanized crop farming, then you should be willing to raise huge capital base to start the business. This is so because some cultivation machines / equipment can be pretty expensive.

Below are some of the basic areas we will spend our start – up capital in setting up our greenhouse commercial farm;

- ❖ The Total Fee for incorporating the Business (Greenhouse commercial farm) in Kenya – Ksh.75,000.
- ❖ The budget for key insurance policies, permits and business license – Ksh.250,000
- ❖ The amount needed to acquire / lease a farm land – Ksh.5,000,000
- ❖ The amount required for preparing the farm land (for construction of greenhouse and hothouse) – Ksh.7,000,000
- ❖ The cost for acquiring the required working tools and equipment / machines / glass/polythene casing e.t.c– Ksh.21,500,000
- ❖ The amount required for purchase of seedlings – Ksh.2,000,000
- ❖ The Cost of Launching an official Website – Ksh.60,000

- ❖ The amount required for payment of workers for a period of 3 months – Ksh.10,000,000
- ❖ Additional Expenditure (Business cards, Signage, Adverts and Promotions etc) – Ksh.200,000

Going by the report from detailed research and feasibility studies conducted, we will need an average of Ksh.35,000,000 to start a standard greenhouse commercial farm business in Kenya.

Basically, the nature of greenhouse commercial farms does not require an office space; most people that run greenhouse commercial farms operate directly from their farms. But if we decide to open a small liaison office; a place where administrative jobs will be carried out.

Generating Funding / Startup Eddie Greenhouse – Farms, LLC

No matter how fantastic your business idea might be, if you don't have the required money to finance the business, the business might not become a reality. Finance is a very important factor when it comes to starting a business such as greenhouse commercial farming. No doubt raising start – up capital for a business might not come cheap, but it is a task that an entrepreneur must go through.

Eddie Greenhouse – Farms, LLC is a family owned business and it will be financed by the owners of the company – Dr. Eddie Madowo and family. These are the areas where we intend sourcing for fund for Eddie Greenhouse – Farms, LLC;

- ❖ Generate part of the start – up capital from personal savings and sale of his stocks
- ❖ Generate part of the start – up capital from friends and other extended family members
- ❖ Generate a larger chunk of the startup capital from the bank (loan facility).

N.B: We have been able to generate about Ksh.10,000,000 (Personal savings Ksh.8,000,000 and soft loan from family members Ksh.2,000,000) and we are at the final stages of obtaining a loan facility of Ksh.25,000,000 from our bank. All the papers and document has

been duly signed and submitted, the loan has been approved and any moment from now our account will be credited.

GREENHOUSE BUSINESS GROWTH: Sustainability and Expansion Strategy

The future of a business lies in the numbers of loyal customers that they have the capacity and competence of the employees, their investment strategy and the business structure. If all of these factors are missing from a business (company), then it won't be too long before the business close shop.

One of our major goals of starting Eddie Greenhouse – Farms, LLC is to build a business that will survive off its own cash flow without the need for injecting finance from external sources once the business is officially running. We know that one of the ways of gaining approval and winning customers over is to sell our farm produce a little bit cheaper than what is obtainable in the market and we are well prepared to survive on lower profit margin for a while.

Eddie Greenhouse – Farms, LLC will make sure that the right foundation, structures and processes are put in place to ensure that our staff welfare are well taken of. Our company's corporate culture is designed to drive our business to greater heights and training and re – training of our workforce is at the top burner of our business strategy.

As a matter of fact, profit-sharing arrangement will be made available to all our management staff and it will be based on their performance for a period of three years or more as determined by the board of the organization. We know that if that is put in place, we will be able to successfully hire and retain the best hands we can get in the industry; they will be more committed to help us build the business of our dreams.

Check List / Milestone

- ❖ Business Name Availability Check: **Completed**
- ❖ Business Incorporation: **Completed**
- ❖ Opening of Corporate Bank Accounts various banks in Kenya: **Completed**

- ❖ Opening Online Payment Platforms: **Completed**
- ❖ Application and Obtaining Tax Payer's ID: **In Progress**
- ❖ Application for business license and permit: **Completed**
- ❖ Purchase of All form of Insurance for the Business: **Completed**
- ❖ Leasing of farm land in Kisii County: **Completed**
- ❖ Conducting Feasibility Studies: **Completed**
- ❖ Start – up Capital Generation: **Completed**
- ❖ Writing of Business Plan: **Completed**
- ❖ Drafting of Employee's Handbook: **Completed**
- ❖ Design of The Company's Logo: **Completed**
- ❖ Graphic Designs and Printing of Packaging Marketing / Promotional Materials: **Completed**
- ❖ Recruitment of employees: **In Progress**
- ❖ Building /construction of greenhouse and hothouse facility: **In Progress**
- ❖ Purchase of the needed working tools, machines and equipment: **Completed**
- ❖ Creating Official Website for the Company: **In Progress**
- ❖ Creating Awareness for the business (Business PR): **In Progress**
- ❖ Farm land Treatment, Health and Safety Arrangement: **In Progress**
- ❖ Establishing business relationship with key players in the industry (agriculture farm produce merchants, transporter / haulage and suppliers of seeds, fertilizers, pesticides and insecticides): **Completed**

** END of our Business Plan**

Wow! That was a nice business plan. So before you start your own greenhouse, write your business plan. A business plan will give you direction of what you are targeting.

Now let's move to Chapter 2 and see how much it will cost us to build a greenhouse.

Chapter 3

Cost of Building a Greenhouse



How much does a greenhouse cost?

How much does a greenhouse cost? It's probably one of the most difficult questions that i receive from my ebook readers every now and then. In this chapter, i will explain a bit more about the parameters that influence the price and cost for a greenhouse.

The cost price of a greenhouse is influenced by many important factors. Before a quote can be made, the location and the climate of the area will need to be examined as it covers one of the most important aspects. Secondly the size of the project matters, just like the type of crop that needs to be grown inside. And then a closer look must be taken at the equipment and technology installed. "This is the basic initial information that is needed before we can even start to calculate any costs."

1. Climate of the area

While greenhouses are able to fully control and create a micro climate in almost any region, it needs be determined whether the climate in the designated area really requires this. What kind of climate does your business model require and what time of the season do you need the climate?

Growers in coast or North eastern will need different greenhouse specifications and designs due to different climate conditions of the area. "You will need to study the local climate beforehand in order to determine what kind of greenhouse model suits the local climatic conditions of the area."

For all these kind of areas and cropping schedules there are several types of greenhouses available. "The differences in required structure and equipment all cause considerable differences in the price of the greenhouse."



Next to this, the local climate also influences the cost of the greenhouses in terms of resistance to local weather conditions. Think not only about temperature, humidity and solar radiation but also big influences like wind, rain or even susceptibility to earthquakes . "A greenhouse in an area with extreme wind or rain conditions causes the price of the structure to rise as it must be engineered in order to withstand heavy winds and rain intensity for example. In

order to obtain a good quotation, you will need to study the temperature, humidity, wind, solar radiation and other environmental factors throughout the year."

2. Dimensions of the project

And then there is the dimension of the project. It is obvious that a larger greenhouse costs more than a smaller greenhouse. But have you thought about the dimensions of the area available. It can sometimes be cheaper to build a square project than a slightly smaller greenhouse with non-standard dimensions and that for example has to fit in between existing structures.

Therefore it is essential to indicate the surface and the shape that the project is going to have in order to assess the price of a greenhouse. There is a difference between the price of a greenhouse with an irregular shape and that of a greenhouse with a regular shape. All details that you can provide in regards to the crop area, location and other information will be helpful to study the project if you are sourcing experts to build a greenhouse for you.

3. Type of crop

Also worth a mention; the type of crop. Flower crops need a different structure than fruiting vegetables. It is very important to know what kind of product is going to be grown in the greenhouse. This influences the model of structure, but also factors like the density of the crop and the distance between the rows will eventually influence the price of the structure.

Each crop type requires different special accessories. There are crops that have a similar production and growth, but other types of crops need a reinforced structure and special equipment (like high wire tomatoes on hanging gutters)."



4. Equipment and technology



Also the technology required to grow a certain crop in a certain location will cover a big part of the cost price. Do you need ventilation, heating, cooling, high pressure fog systems, shading screens, energy screens, irrigation, hydroponic systems, artificial lighting, CO₂ supply, automation? All this technology increases the price of the greenhouse obviously.

5. What Size Greenhouse Are You Planning?

Consider the size. Obviously, a larger greenhouse will require more material, which will increase the cost. But what size do you need?

For the serious gardener or horticulturist, a 10x10 greenhouse is the minimum size. For the casual “greenie”, 6x6 is usually fine. If you aren’t sure, opt for a larger space. You will fill it up easily, and it’s difficult to add-on to an existing smaller structure.

a. Basic Beginner

About Ksh.24,000



A basic beginner’s greenhouse is fairly inexpensive. A 6’x8’ hoop-house (an arced greenhouse) package has everything you need to build it yourself and get started. This, however, is a very basic design more for moderate climates. It doesn’t have any plumbing or electronics, being essentially a polyethylene-covered Quonset hut.

B. Experienced Growers

About ksh.50,000 to Ksh.200,000



For the more dedicated grower, a 12'x12' greenhouse might be more suitable. For this type, there are many extra costs involved including grading the foundation, laying the floor, and running plumbing and electrical systems. They're usually best installed by a professional and might require permits. The siding is usually polycarbonate or glass with a vented roof for temperature/humidity control.

C. For the Serious Grower

About Ks.250,000 to Ksh.500,000 and above



The average cost for a greenhouse structure (except for kits) is about Ksh.2,500.00 per square foot. These large greenhouses are 500 to 1,000 square feet. They usually have all of the amenities a plant could hope for. HVAC (Heat, Ventilation and Cooling) systems maintain

temperature and humidity for some, while computers and sensors automatically open or close roof vents and windows. Automatic watering systems and feeders provide nutrition, and grow lights help provide optimal conditions. Flooring is often poured concrete with drainage systems. These greenhouses should be professionally installed.

6. Material Options

The materials used will have the biggest impact on your cost. Frames are usually made of wood or steel. Siding runs the gamut from polyethylene to tempered glass. Each material has its pros and cons.

a. Glass

Double strength (minimum recommended) about Ksh.250 sq. ft.



Glass is the preferred siding for greenhouses. Not only is it beautiful, it also gives your structure a look of permanency.

Advantages

- ❖ Visually attractive

- ❖ Excellent heat conductivity
- ❖ Doesn't need replacing unless broken

Disadvantages

- ❖ Doesn't diffuse light, therefore can burn plants
- ❖ Heavy, requires a strong frame

Maintenance involves cleaning the same way you would the windows on your home, but also inspect periodically for cracks, chips, and breaks, especially after a strong wind or rain storm.

B. Polyethylene

About Ksh.12 per square foot



Polyethylene is a plastic film used as siding on many greenhouses. Its flexibility makes it popular for hoop-houses.

Advantages

- ❖ Very inexpensive

- ❖ Can fit any shape

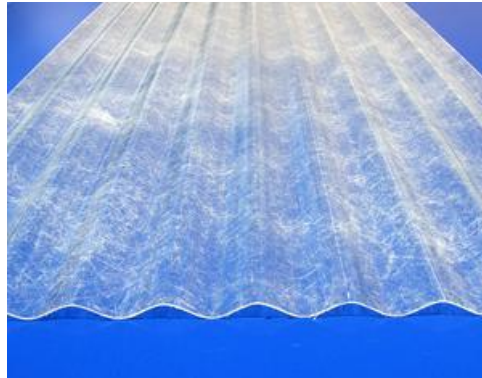
Disadvantages

- ❖ Must be replaced every couple of years.

Maintenance requirements include routine hosing off and inspecting for tears. Tears can be repaired easily with patches of the same material and packing tape, with patches applied to both sides of the tear. If it's getting yellow and brittle, it must be replaced.

C. Fiberglass

About Ksh.7,200 per 6x8 panel



Fiberglass is light but rigid while allowing a degree of flexibility, making it a fairly popular choice.

Advantages

- ❖ Light and sturdy
- ❖ Provides excellent light diffusion

Disadvantages

- ❖ Expensive
- ❖ Can crack in high winds

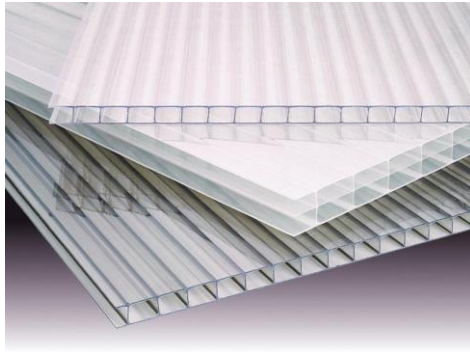
Maintenance requirements include routine hosing off and inspecting for cracks and breaks, especially after storms. Fiberglass patch kits cost less than **Ksh.2,000**

D. Polycarbonate

About Ksh.5,500 per 8x4 sheet



Polycarbonate is a good alternative to glass. Light and rigid, it's almost as transparent as glass, but the double-wall construction insulates against burning.



Advantages

- ❖ Transparent but insulating
- ❖ Doesn't require a heavy frame like glass does
- ❖ UV additives protect it from deterioration

Disadvantages

- ❖ Scratches easily
- ❖ Doesn't cut easily for sizing
- ❖ Repairs are only temporary until you can replace the whole panel

Maintenance involves inspecting for cracks and replacing panels if necessary.

7. Framing



One of the most essential parts of the greenhouse is the greenhouse frame. Without a good, solid frame, the greenhouse will not stand well and could possibly collapse. Fortunately, there are a wide variety of materials to choose from when it comes to making a greenhouse frame. Each material has a number of different benefits, and understanding the choices available should help you make an informed decision prior to the assembly of your own greenhouse.

a. Wood

Cedar or eucalyptus, about Ksh.100 per linear foot



Wood framing provides a natural look for a greenhouse, attractive while blending in with your landscape. Cedar is recommended for its outdoor durability.

Advantages

- ❖ Beautiful and durable with regular maintenance
- ❖ Naturally insulating, won't draw heat away from plants
- ❖ Easy to work with

Disadvantages

- ❖ Can attract insects
- ❖ Treated wood should be shielded so that rainwater and other moisture doesn't drip onto plants

Maintenance involves annual treating and sealing, the same as you would a deck.

Steel

About Ksh.250 per linear foot



Steel frames are stronger than wood, but are more expensive and harder to work with. A 20' hoop-house steel frame costs around ksh.56,000 and doesn't include the covering or end walls.

Advantages

- ❖ Stands up to adverse conditions very well
- ❖ Low maintenance

Disadvantages

- ❖ Harder to work with than wood
- ❖ Draws heat away from plants.

Maintenance involves periodic inspections for rust and replacing rusted parts.

8. Excavation



While many greenhouse kits come with flooring, building your own will require you to level the ground at the very least. Some people leave a natural dirt floor, but this can become a muddy mess. Most people use some kind of flooring, often concrete, pavers, or gravel.

- ❖ Concrete – About Ksh.1,000 per square foot, should have texturing and drainage
- ❖ Pavers – About Ksh.800 to Ksh.1,100 per square foot on average
- ❖ Gravel – About Ksh.75 to Ksh.300 per square foot, but will require weed-block or constant weeding

9. HVAC, Lighting and Permits

Temperature and humidity controls for your plants is a must. A smaller greenhouse might do well with the gardener or horticulturist handling this manually, but larger greenhouses might fare better with HVAC and lighting systems.

Because these systems must be installed by licensed contractors, they can make up half to more than half of your project's total cost. A large, Ksh.500,000 greenhouse could easily have over Ksh.250,000 in lighting and HVAC systems.

Grow lights cost from Ksh.3000 to Ksh.13,000 each. HVAC systems cost from around Ksh.10,000 for a simple, portable heater useful in small areas to several thousand shillings for a full system.

DIY Considerations

If you know what you're doing, you can build your own greenhouse. Many sites offer free plans; all you have to do is buy the materials. Here are some other considerations:



- ❖ Use salvaged materials. If you want to recycle and go green, re-using old material is a great way to go. You'll have to clean the material and alter either it or your plan to make it fit, but the material is usually free.
- ❖ Learn about the climate where you live. In a cold area you'll need insulating materials. In a hot area, you'll need to provide for shade. Usually, you need a bit of both.
- ❖ Don't forget air circulation, pest control, and temperature control.
- ❖ Be sure your greenhouse gets plenty of sunlight, but remember to have a shade cloth if needed.
- ❖ The type of covering you use will determine the strength of the frame needed. Polyethylene can use a lighter frame, but glass will need a stronger one.
- ❖ Remember to anchor your greenhouse firmly to the ground or the slab. High winds can cause a catastrophe.
- ❖ If you want "all the extras", you can mitigate the cost by adding them slowly over time.
- ❖ Take advantage of "good bugs" to help protect and fertilize your plants.
- ❖ Include storage space in your design.
- ❖ Set aside the time to build it right. A small greenhouse might take a weekend or less, but larger ones can take several weeks.
- ❖ A simple 165 square foot hoop house can be built as cheaply as Ksh.5,000 to Ksh.13,000.

In Conclusion

Finally, building a greenhouse in your area might require a permit. It is considered an "outbuilding" or a "farm building" and may need to be permitted before construction starts. Check with your county enforcement office. Failure to get a permit could result in fines.

For the hobbyist or serious grower, a greenhouse is a requirement. With careful planning, it can be attractive and affordable.

Hopefully this chapter has explained to you a bit more which data and factors that are required before a greenhouse builder/expert can tell you about the needed capital to buy or construct a greenhouse.

Chapter 4

Selecting Your Greenhouse Location



Where you place a new greenhouse can make the difference between growing success and failure, so it's important to get it right. With careful siting, it should be possible to optimise the productivity of your structure, which helps to offset your initial outlay and justify the space it takes up in your garden.

Of course, it may be that there is only one possible place you can put it, but if you do have a choice, it's well worth giving it the best possible position you can. It may seem a shame to sacrifice a prime location or an already productive spot in your garden, but when you weigh up the increased benefits you'll get from protected cropping, it's a sacrifice worth making.

Think about what you want to do with your protected structure, and what the needs of your plants will be. If you're planning to grow crops all year round, raise seedlings or overwinter

tender plants, you'll need a spot with maximum light and sunshine, away from frost pockets and cold winds.



Selecting a proper site for your greenhouse is just as important as selecting your construction materials, seeds, plant nutrients, and countless other components needed to ensure success.

Determining the site of a greenhouse operation involves numerous considerations before actual construction of the facility. Although this fact chapter is intended to guide the entrepreneur in selecting the site, it also can be used as a checklist when buying an existing greenhouse.

Before starting, it is important to have an idea of the type of plants you want to raise and sell and a decision as to whether you wish to be retail or wholesale. As many aspects should be considered when choosing a site, what follows are factors to take into account before you make this important decision.

1. Solar radiation:

Since plants require light for photosynthesis, it's critical to determine how the sunlight will reach them. Low light reduces photosynthesis and causes slow growth and fruit and flower abortion. The result is a low yield and minimal financial return. The location of your greenhouse and the time of year make a big difference in photosynthesis; locations that don't receive enough solar radiation will need supplemental lighting.

Search for an area that is free of any potential shading from nearby structures or trees. A rule of thumb to follow is to avoid construction any nearer than 2.5 times the height of the nearby object. Removal of the shading object may be a more feasible alternative. This will apply to eastern, western, and southern exposures.

Place the greenhouse with the ridge in a north to south orientation to reduce interior shading from the structure itself on the plants.

2. Water:

About 1 gallon of water mixed with nutrients is needed daily to supply each plant in addition to the water needed for evaporative cooling, which is about 10,000 to 15,000 gallons an acre each day. You can recycle nutrient water to increase your water use efficiency, but be wary of salt build-up.

An initial water analysis should be done to assess salt and pH levels. pH levels should be adjusted to around 5.8 to 6.5 for tomatoes and if the source water is basic, as in more than 7 parts per million, add acids such as nitric, phosphoric, and sulfuric. If the source water is acidic, as in less than 7, add a base.

3. Elevation:

Elevation affects high and low temperatures and will affect your cooling and heating costs, as well. For example, tomatoes function best between temperatures of 59°F to 86°F. If you happen to be at a higher altitude, here are several tips on how to control the temperature:

- ❖ Place plastic jugs of water around the plants when it's cold. The water will garner heat during the day, and hold it during the night when the temperature drops.
- ❖ Place a temperature alarm in the greenhouse during colder months to alert you when the temperature drops. If necessary, you can place a ceramic heater in the house to increase temperature.
- ❖ If you have a rigid structure, use an automatic vent opener to control the heat, and if you have a soft structure greenhouse, you can open a flap to permit heat reduction.
- ❖ During the hot season use an automatic water system, possibly one that includes misters. During the cold season disconnect all hoses to prevent pipes freezing up and water instead by hand.

4 Microclimate:

There are many different factors that can affect your environment including latitude. Sea level at the poles will always be colder than sea level at the equator, and large bodies of water will heat up and cool down much slower than land masses. For example, Mombasa, which is next to the Indian Ocean, has much smaller fluctuations between day and night temperature than does the North eastern area, which is not close to a large body of water and whose temperatures can fluctuate.

Take trees, mountains, and other obstructions that could possibly cast a shadow on the greenhouse into consideration, especially in the morning. Mountains also have the ability to affect wind and storm patterns.

Other environmental considerations include: clouds and fog, which can gather at certain times of the day in specific areas and reduce sunlight and photosynthesis; high wind that can cause structural damage and suck heat away from the greenhouse; blowing dust and sand which can braze the greenhouse glazing.

5. Pest pressure:

Make sure to either choose a site that is far away from other agricultural production areas, or create a buffer zone between your operation and other production areas to prevent pest infestation.

6 Level and stable ground:

Be aware of the stability of the ground on which you construct your greenhouse; it should not be subject to shifting. The ground must also be graded for water draining (a 6 inch drop in 100 feet). Additionally, the ground must be compacted so that it won't begin to settle after the greenhouse is built.

7 Utilities:

Make sure that you have the following utilities at your disposal:

- ❖ Telephone service
- ❖ Three-phase electricity
- ❖ Fuel for heating/CO₂ generation: natural gas, propane, fuel oil, electricity.
Alternatives include solar, compost, woodchips, nut hulls, etc.

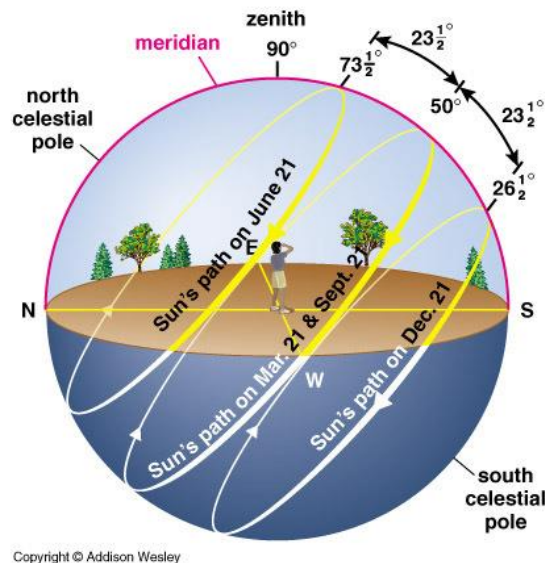
8 Roads:

Access to good roads is a must. For example, if roads are unpaved, when you transport your harvest, the fruit will be subject to all of the rocky movement of the vehicle which could lead to bruising, crushing, and other major damages for your fruit.

9 North-South orientation:

If possible, the greenhouse should sit on elevated ground with a slope; this will move water away from the structure and help prevent flooding. Furthermore, the orientation of the structure will determine how much sunlight is taken in. *Ideal orientation will depend largely on which hemisphere the greenhouse is located in.

The structure will need to be oriented so that light interception is maximized during cold months—taking into account the sun’s path. *Orientation refers to which way the ridge (the length) of the greenhouse runs.



It is important to note that the sun’s greatest height above the horizon always occurs at noon; and this (greatest) height is different according to the season, hemisphere, and latitude. It

is always highest in mid-summer, and lowest in mid-winter. *In the winter, the sun stays close to the horizon.

Studying the sun's path, one finds that—in northern latitudes (above 40 degrees) an east-west orientation works best to catch maximum light during winter, because it allows winter sunlight to penetrate the entire length of the greenhouse's south side.

The angle of the sun-collecting side of the greenhouse is another important factor, as it also affects sunlight interception. *The optimal angle of your sun-collecting side can be determined simply by adding 20 degrees to your latitude.

10 Greenhouse Expansion

A common oversight in greenhouse construction plans is the possibility of future expansion. By planning for a larger operation in years to come, the need for relocation may be avoided. Most greenhouse ranges will double in size within a few years and even greater expansion should be anticipated.

11 Availability of labor:

The owner or manager of the operation will need two different types of labor forces:

- ❖ Trainable laborers as a retainable workforce. These laborers will take care of the plant and fruit harvesting and packing.
- ❖ Specialty laborers. This includes growers, plant production managers, plant nutrition specialists, plant protection specialists, office/computer specialists, labor/management specialists, and marketing specialists.

12 Management Residence:

Growers and managers should all live relatively close to the greenhouse in the event of an emergency.

13. Land

The site should be naturally level. This will decrease initial grading costs. If possible, the land should also be large enough to accommodate expansion without excessive grading.

The ideal tract of land has a slight slope, up to five percent, which provides for proper air circulation and excess water runoff. If the soil has a high clay content, a greater slope may be needed. Otherwise, considerable expenses may be incurred to provide an elaborate drainage system. Determine if frost pockets exist in low lying areas and if flooding has occurred on the site. Low lying areas or valleys can sometimes exaggerate the effects of cold and hot air flow.

Soil is an important factor to consider. Ideally, a sandy or silt loam soil with high fertility and good drainage is recommended for container production. Soil is seldom used alone as a container media, but rather in a mix with soil-less amendments. In fact, many businesses grow plants with entirely soil-less mixes.

Proper soil drainage is vital for growing plants in ground beds. Without proper drainage a number of problems will develop that may be insurmountable to the beginning grower. High salts and insufficient soil aeration are a couple of the obstacles that may be encountered.

A media pH ranging from 5.5 to 6.5 is acceptable for the production of most greenhouse stock. The pH can be lowered by adding elemental sulfur or aluminum sulfate. However, raising the pH is more feasible and can be accomplished by adding dolomitic limestone. This is

commonly used to correct soil-less mixes that are excessively acidic. Correct soil pH provides for maximum plant utilization of the soil's nutrients. The Department of Agronomy at Oklahoma State University will test soil pH and nutrient status at a reasonable cost.

14. Make attending to your plants easy

It's best to place your greenhouse close to a watering source as you will be watering your plants regularly. While not essential, it's also a good idea to keep it close to your house so it's easier to attend to the plants – your greenhouse will get more use, and the plants in it will get more care if you have easy access.

Chapter 5

Construction of Your Greenhouse



Think it would be tough to build your own greenhouse? Not so much!

If you're just moderately handy at using simple tools, a greenhouse project can be a great way to start greenhouse gardening. If you're interested in greenhouse gardening, building your own greenhouse certainly isn't the *only* way to get started.

If you want a greenhouse, obviously you could hire a company to build you a beautiful and elegant greenhouse. That would certainly be the easiest way to get a greenhouse. But it would also be the most expensive way.

Do it yourself greenhouses, on the other hand, allow you to trade a bit of time and elbow grease for a cheaper start on gardening with a greenhouse. I will teach you in this chapter how to

construct your own greenhouse and also if you can't do it by yourself, i will provide you contacts of Kenyan greenhouse building companies who will help you build a greenhouse at a cost.

A Few Things to Consider if You Want to Build Your Own Greenhouse...



If you're interested in a do it yourself greenhouse, you'll find yourself faced with a wide array of choices.

That's a good thing, of course. It's always better to have lots of options to choose from. The only downside, though, is that it makes the 'getting started' process a bit more complicated. All of those options have to be sorted through before you can decide what's best for you.

In fact, if you decide to build your own greenhouse, you might actually find the decision making process to be the most difficult part of the whole project.

Decisions, Decisions...

For example: Do you want to build your own greenhouse from scratch, or would you prefer to purchase a greenhouse kit? The cheapest route, of course, would be to build from scratch. But you can get a very nice, easy-to-assemble kit for quite a reasonable cost. A greenhouse kit can offer a nice compromise between cost and convenience.

And then once you've decided between scratch-built vs. greenhouse kit, there will be lots of additional decisions to make.

You'll need to decide upon the style of greenhouse you want, the size, the complexity – and if you're buying a kit, you might even have to decide upon a color!

If you're going to build your own greenhouse from scratch, what type of material will the framework be – wood, steel pipe, aluminum? Did you know that you could even build a greenhouse out of plastic pipe?

And More Decisions!

Once you've waded through all those decisions, then you'll need to decide how to equip the greenhouse. Will you need exhaust fans, and if so, what size? What about constant air circulation fans? How about benches, misters, light sensors and all the other gadgets and gizmos that can be part of greenhouse growing. These all add to the expense, of course – AND to the fun!



You might want to have nothing more complicated than a simple structure that will allow you to grow plants directly in the ground, with ventilation consisting of nothing more than rolled-up sides and open door flaps. You might be surprised at how cheaply you can get started that way.

But you might want to go whole hog with a hydroponics system and automated climate controls. Careful, though. You might be surprised at how *much* you can spend when you start assembling that wish list!



What Are Your Greenhouse Gardening Goals?

Yep, more decisions!

What would you like to grow in your greenhouse? How much of it? Do you want a year-round greenhouse, or just a transplant (seedling) greenhouse?

Even though you may be planning on building just a small greenhouse in your backyard, don't rule out the possibility of making a bit of money from your hobby. That's very doable if you're interested in going that route. (I can assure you, neighbours will pay a pretty penny for homegrown, garden quality tomatoes and other produce.)

Or perhaps you have a really large backyard, or maybe even a small acreage, and you're considering a large-scale greenhouse project.

All of these choices will dictate other decisions, and the whole thing becomes sort of an interwoven mesh (*I said m-e-s-h, not m-e-s-s, though by now you may be thinking it seems more like the latter!*).

I'll Help You Sort Through the Choices

As you can see, a big part of building your own greenhouse has to do with choices. Facing them and making them. Before ever a hammer is swung or a purlin is strung, you'll want to be sure that you've made decisions that will best work to accomplish your greenhouse gardening goals (once you've figured out what *those* are, of course!).

But don't let that bewildering array of choices deter you from getting started. Don't fall victim to 'paralysis by analysis.' I'll try to help you by providing lots of solid information so that you'll be making informed decisions.

And in reality, the decision-making is really a fun part of the process. Yes, there certainly are lots of decisions to make. But oh, the possibilities, and the wonderful dreams they inspire!

...before we begin:

If this is the first time you're building a greenhouse and growing plants in it, you might want to consider getting some greenhouse plans.

If you love building things by yourself, or at least want to give it a try, you should check the below greenhouse plan.

The 'Hoop' Greenhouse



This design has a round formation. It is very simple to build and is less complex than most.

It requires very little tools but the tools that are needed are listed along with the plans. Most people that build this form use it in a cold frame fashion. You can add grow light to it if you choose, though.

This is the type of greenhouse I built for my mum at home 3 months ago. You can read all about how you can build yours for less than Ksh.20,000. If you are looking for an inexpensive option, this is a great fit.

How to Build an Inexpensive Hoop-Style Greenhouse

One of the most valuable assets in my mum`s garden is her hoop style greenhouse. It has allowed her to grow plants that she normally would not be able to grow, produce crops that the season is not usually long enough to produce, and protect her plants from frosts, hail, or other severe weather that normally would have destroyed her garden.



Most agribusiness minds i interact with usually tell me “I don’t have thousands of money to spend on a greenhouse. I just priced out an 8’x12’ greenhouse for Ksh.35,000. I would love to have a large, professional greenhouse, but that simply isn’t financially feasible for me.” So, instead I’ve found a way to make a large greenhouse that is functional, easy to build, and inexpensive. This section will explain to you exactly how to build a 12’x32’ hoop-style greenhouse for under Ksh.40,000.

Required Materials List

Note: All wood should be green, treated wood to resist rot. (Or you can spend more money and buy a rot resistant type of lumber such as cedar.)

- ❖ (4) 2x6 – 16’
- ❖ (2) 2x6 – 12’
- ❖ (14) 2x4 – 12’
- ❖ (19) ¾” x 20’ white pvc pipe
- ❖ (9) 10mm x 10’ rebar
- ❖ (1) 20’x50’ roll of 6mm plastic
- ❖ (1) Bundle of 50 4’ wood lathe (or optional staples)
- ❖ Zip ties
- ❖ Nails or screws
- ❖ Metal banding
- ❖ Door hinges and handles

Step 1 – Laying Out the Frame

Using the 2x6s, lay out and put together your 12'x32' frame. (You can join the two 16' pieces with a 2' piece of 2x4.)

Ensure that the frame is square by measuring diagonally across it. You can temporarily keep the frame in place by pounding a 30" piece of rebar in each corner. (You can pull these out to use them in the next step.)



Step 2 – Adding the Hoops

Cut each 10' piece of rebar into four 30" pieces of rebar. This will give you thirty-four pieces. Pound the rebar into the ground about 15" deep on the outside of your frame at two foot intervals. This will leave 15" sticking up out of the ground.



Now slide both ends of your pvc pipe over the rebar to make a hoop across the width of your greenhouse.



Attach the pvc pipe to the 2x6s by screwing short pieces of metal banding around the pipe.



Step 3 – Building the Ends

Cut the following pieces out of your 12' 2x4s:

- ❖ (2) 11'8³/₄"
- ❖ (4) 1'6"
- ❖ (4) 4'7"
- ❖ (4) 5'7"
- ❖ (8) 1'11¹/₄"
- ❖ (2) 4'1¹/₄"

For each end, assemble the wall according to the following diagram.



Place this wall within the 2x6 frame and nail/screw in place.

Cut (4) 28" 2x4 pieces. Cut one end at a 45° angle. Use these pieces to brace the wall.



Once all of the hoops and the two ends are in place, connect two pvc pipes together and cut them to measure 32' long. This will be the rib that will go along the top of your hoops. You can attach this rib with plastic zip ties.



Step 4 – Covering the Greenhouse with Plastic

If you are going to use wood lathe, cut 32 pieces of 20” lathe. These will secure the plastic to the sides of the 2x6 frame in between each hoop. Or optionally, you can use staples, though they may have a tendency to pull through the plastic.

Drape the plastic over the length of the greenhouse. Be sure to have enough overlap at the ends to cover the end walls. Pull the plastic snug and attach to the 2x6s at one end using the wood lathe or staples. Go to the other end, pull snug, and attach in a similar manner. Do this at the center, and then along the rest of the length of the greenhouse.



Note: If you can do this in warm weather, there will be less sagging later. Make it as snug as you can without causing damage to the plastic.



To attach the plastic to the ends, pull the plastic straight down, and attach with lath. Then pull the plastic out to the sides. This will give you extra plastic along the outside edge. Fold the plastic back towards the center and attach. For the end with the door, cut out the plastic leaving a few inches of over hang to wrap inside and attach.



Step 5 – Adding the Door

Before you cut your pieces, check the actual measurements for the space you have. Your wall may sit a little different than mine. It's always better to go a little small or your door may not fit. But if the measurements are the same, cut the following pieces out of your 12' 2x4s:

- ❖ (2) 4'11"
- ❖ (2) 3'9"

Nail these together to make your door frame. Lay a 2x4 diagonally across the frame and nail in place. Trim off anything that hangs over the frame of the door. This will be on the inside of your door. Too much wood hanging over will jam your door. Attach the hinges to the door frame.



Cover the outside of the door with remaining plastic or you can use plywood if you would rather. You can attach the plastic with the wood lathe or staples. There should be about 4" of overhang of plastic on all sides.

Attach the door handles to the door. Mount the door to the frame.



And there you go! You can have a beautiful 12'x32' hoop-style greenhouse that can be built in a weekend and all for less than Ksh.40,000.

If you would like you can make it big and bigger by increasing amount of materials used.

If you can't build a greenhouse by yourself or you need a big one that requires experts to build, below i will give you contacts of greenhouse building companies in Kenya.

Greenhouse Building Companies in Kenya



The best greenhouse supplier in Kenya is Amiran, it is located in Old airport north road, Box 30327-00100 Nairobi – Kenya, Mobile: 0719 095 000/+254 20 824837. Email: pr@amirankenya.com. The company has constructed over 90 percent of greenhouses used in the flower farmers and horticulture projects.

The company manufactures tailor made greenhouses which are appropriate for the project. The green houses manufactured include coral 11200 and Emerald. The green houses made are perfectly designed for extreme tropical climate, they are covered with polythene film and they are designed to meet international standards which are the ability to withstand wind, the overlapping vent in the green house will prevent rain penetration. With the rising demand of the greenhouses due to more people starting farming projects, farmers should consider the following factors before choosing the greenhouse supplier.

The cost of starting greenhouse project

Since the greenhouse projects are mostly started with the intention of making money, then one should think of how they will manage the project financially. You should be aware about what you will be expected to pay. Some suppliers will quote the price of the green house

alone leaving out other essentials like water tank, drip lines and seeds; other will quote the total cost inclusive of all those packages.

As a farmer who is after money you should go for the supplier who is giving a complete quote in order to avoid hidden cost and the cost of purchasing the rest of the equipment's needed. The supplier should give the details of installation, whether they charge the installation or they give the after services for free. In case of new and inexperienced farmers consider technical support before making the final choice of the supplier. Some suppliers will offer the structure and refer you to other suppliers where you will get the materials at an affordable price.

Customer service

Consider the terms of the supplier to know if they offer technical help, some suppliers will offer the service for free while others will charge for the services. It is very important to get information about planting methods, pruning and other essential farming activities.

It is good to consult the supplier when you do not have enough expertise in the project you want to start. Farmers are advised to attend training before they start their projects and train their employees to know what they are supposed to do, greenhouse supplier may not have time to train you because their objects is making a sale and after you have closed the deal they will have accomplished their mission.

The structure

Structure of the green house is very important this will include details like the height and the length, make sure you study the demonstration or the showroom. The type of the crop you grow will dictate the size of the greenhouse, like in the case of tomatoes there are those which grow upwards.

Details of the Farm

Factors like the size of the farm and the soil type should be considered before, most greenhouses come with water tanks, the farmer should work out ways of pumping the water to the tank, try to minimize the cost by avoiding using fuel to pump water for this will reduce the profits. The type of the soil can be reduced by using fertilizer or manure which should be added before planting, it is good to do soil testing in order to get the details of soil type, testing of soils is done at KARI at a cost of Ksh. 500.

1. Illuminum Greenhouse Company



They are an Agri-Tech greenhouse and drip installation company in Kenya working with smallholder farmers to improve production and increase efficiency through the use of new modern technologies.



They construct affordable modern greenhouses and install automated drip irrigation kits for smallholder farmers by using locally available materials and solar powered sensors.

Here are there services tailored to your preference.

1. SOIL TESTS

Test your soils before planting for mineral content and pathological analysis.



2. AGRONOMIC SUPPORT

Plant high value seeds and receive expert agronomic care with e-reports

3. PRE-SITE SURVEY

Get a professional technician visit your farm and determine suitability.



4. DRIP IRRIGATION

Farm all year round with high quality affordable drip irrigation kits.



5. GREENHOUSE CONSTRUCTION

Construct affordable modern greenhouses.



6. SENSOR TECHNOLOGY

Optimize operations and production in your farm with solar powered sensors



You can reach them at the following addresses:

HEADQUARTERS: M-Lab 3rd Floor, Bishop Magua Centre, opposite Uchumi Ngong road.

Kitengela Branch: Kitwoods Building, Suite 3-Ground Floor, Next to Kaputei Hotel, along Nairobi-Namanga Road.

From Monday to Friday, 8:00am – 5:00pm & Saturdays, 9:00am-1:00pm. Sundays, CLOSED. call them from 8:00am-11:00pm through: +254732613501 or +254732613531

EMAIL them on info@illumiumgreenhouses.com

2. Green Tec Irrigation

At Green Tec they have various greenhouses for sale and costs of constructing a greenhouse in Kenya vary depending on sizes and materials used in constructing a greenhouse as well.

GREENHOUSE PRICE LIST

- ❖ 4 x 5m costs ksh 95,000,
- ❖ 6 x 10m costs ksh135,000,
- ❖ 6 x 12m costs ksh155,000,
- ❖ 6 x 15m costs ksh195,000,
- ❖ 8 x 15 cost ksh.225, 000,
- ❖ 8 x 25 cost Ksh. 295,000,
- ❖ 8 x 30 cost ksh.345,000
- ❖ 8 x 30 cost ksh.395,000
- ❖ 8 x 45 costs Ksh.555, 000.
- ❖ 8x 60m cost ksh.895, 000

These are local rates inclusive of

- ❖ - construction
- ❖ - water tank
- ❖ - drip kits/ drip lines
- ❖ - technician support
- ❖ - transport within Nairobi
- ❖ - complimentary seeds

1. Covering

The Tunnel is covered with EVA plastic film, 150 or 200 microns with UV-protected function that can last for 1 year and can be used for 3 years.

The purpose of greenhouse cover is to separate the inside from the outside environment and to transmit as much light as possible. The film optimizes light transmission and plant growing processes. Enough light stabilizers is added to enhance the life of the film. Unique among these covering materials are multi-layered polythene films often referred to as “EVA films” that include 10% EVA, UV inhibitors and colorants to filter or enhance light quality, additives that offer anti-drip and anti-disease properties, as well as cooling and thermal benefits, with diffusion which is ideal for tropical conditions of east Africa

2. General

2.1 foundation- Foundation concrete to anchor the stabs will be supplied by client. The quality of the concrete should be as per the bill of quantities. The proportions should be in the ratio 1:3:6 and a diameter of 8” or 200mm

2.2 steel structure- The whole tunnel is constructed with steel pipe, anti-rust treated, and guarantee for 1 years. The pipe thickness is 1.2mm, with 32mm diameter. The connections of the tunnel are by clamps, bolts and nuts, no welding is done.

2.3 film locking system single ‘D’ locking profiles for the roof arch ridge, lower purlin left side and right side and both the movable vent arm with c profile and ‘W’ plastic coated and UV stabilized spring option.

OUR SERVICE- Wherever possible we survey the site and examine the pre-construction, and do the designs at a small fee.

The structure is developed for easy installation and there is very minimal parts/clamps, resulting to very limited chance of maintenance or failure, but still, there is a full range of spares for any future replacements.

Below are images of some of the greenhouses they have constructed.







Contact

Location: Office: BVR House, 5th floor, Muthithi Road, Westlands

Workshop: Airport North Road, Nairobi, Kenya

Tel: 254-733835308 Email: greeninitiatives2@gmail.com

3. Greenhouse Kenya company (hortitechno produce and services)

This is a Kenya greenhouse construction company based in Nairobi and Kisumu . Greenhouse Kenya company provide a modern greenhouse technology in farming in Kenya , Uganda and east and central Africa as a whole.

Greenhouse Kenya company services range from greenhouse construction, Agronomy, outdoor drip irrigation. They provide one season full agro support and follow-up visits upon installation of the greenhouse.

Greenhouse Kenya company, greenhouse package contain Startup Agro-chemicals, fertilizers, seeds, protective gears, transportation, and installation.

Below are images of some of the greenhouses they have constructed:







Why their greenhouse is the best in Kenya

With hortitechno produce and services greenhouses you get the best produce in horticulture.

- ❖ Their greenhouses are high with a side length of 7 feet and above, you can walk on the sides and it has more room for plant growth and production with the apex of between 4.3 to 4.5 meters. this also allows good air circulation which promotes good regulation of temperature and reduces fungal diseases infection.
- ❖ Their greenhouses are strong and made of stronger galvanised compared to galvanised steel, it withstands high wind speed and durable last for over 20 years with changing of the cover after every 5 years.
- ❖ Their structures are covered with durable u.v treated polyethene with good insect net to screen out *tuta absoluta*, white flies among other insects.
- ❖ Their greenhouse is easy to dismantle and assemble, hence it can be relocated with ease.
- ❖ The Wooden greenhouse comes with crop support in them, strong, high, flexible in any size and can be custom made to fit any space and durable.
- ❖ Construction of their structure is between 3 to 1 week depending on the size.

In Hortitechno produce and services, they understand the agronomic expertise involved in having a greenhouse for better produce.

Contact them on: kenya greenhouse and irrigation company (Hortitechno produce and services.) Tel: +254-723053026

Beat greenhouse costs with Sh40,000 kit

“The greenhouse buzz got to me in 2009. I erected a greenhouse on a quarter acre of my backyard and started planting tomatoes. It is the most profitable venture I have ever engaged in,” said Monicah Rosana.

Rosana, a greenhouse farmer in Ngong, harvested 11,000 kilos of tomatoes the first time, which she sold for Sh110,000. “I had purchased my 8 metre by 15 metres greenhouse at Sh.150,000,” she said.



She increased the tomato seedlings under her greenhouse, and added capsicum and broccoli. “The tomatoes matured after 75 days and I harvested 2,200 kilos, which I sold for Sh.100 a kg, earning about Sh.220,000,” she said.

In a country where about 80 per cent of the country is arid and semi-arid, greenhouse technology is the way to go in harnessing the potential in agriculture. Unlike outdoor farming, greenhouses keep pests and harsh weather at bay, making the land conducive and allowing farmers to get high yields.

Horticultural produce like tomatoes, lettuce, broccoli, onions, flowers and capsicum do very well under greenhouses. And as the technology advances, you can now get started with a Sh.40,000 miniature greenhouse kit, an initiative of the Kenya Agricultural Research Institute.

Retail prices for bigger kits begin at Sh.100,000. Raphael Ngari, a farmer trained at KARI's Thika branch, assembles such structures. "A greenhouse that is 8m by 15m goes for Sh.100,000, and includes the cost of materials for construction, a drip kit for irrigation together with the tank, seeds, fertiliser and soil preparation that entails solarisation to kill pests and disease-causing organisms," he said.

Plant trees "The timber and poles are first coated with wood preservative to safeguard them from termites. The poles are secured to the ground with cement to guarantee the structure a lifespan of at least five years."

The Embu farmer uses ultraviolet-treated polythene paper to complete his structures. The purpose of greenhouse cover is to protect the crops from the harsh and unpredictable external environment, while transmitting as much light as possible.

Ngari designs greenhouses specific to the temperature and weather patterns of an area, such as a high roof for hot areas and lower roofs in cold regions. He first utilised his greenhouses to plant trees.

"I planted 1,000 tree seedlings in August last year in my 8m by 30m greenhouse and harvested over eight tonnes of young trees. I sold these for Sh.380,000 in June this year." The most common sizes of greenhouses in Kenya are 8m by 15m, 8m by 30m and 8m by 60m.

Plants grown in a greenhouse mature faster than those grown outdoors. Faster maturity For instance, greenhouse tomatoes can mature in two months, while the minimum time taken for those farmed outdoors is three months. Greenhouse tomatoes also enjoy a 21-day shelf life compared to 14 for those grown in the open.

Ngari's tips for farmers interested in purchasing greenhouses are: "Make sure the structure is constructed parallel to wind direction to ensure the plants inside are not ruined. Also, the outside must have translucent polythene and the inside be padded with a net to keep pests and birds that can destroy the crop away. You can also lower construction costs by up to 40 per cent if you grow your own trees for timber."

During last year's Nairobi International Trade Fair, several exhibitors of greenhouse technology said it was becoming more attractive to Kenyan farmers. Moses Khaemba of Hortipro Limited said its advantages include crop protection from weather extremities like frost and wind, limited exposure to damaging pests, higher and more consistent production per acre — which translates into more profits, natural sunlight and ventilation, and more economical water usage.

Kari mini-greenhouse ups yields for small-scale farmers

Small-scale farmers can now farm all year round and maximize their yield, while using less farming space and pesticides, this is promised by the launch of a miniaturized green house developed by the Kenya Agricultural Research Institute (KARI).

Greenhouses have long been an icon of Kenya's large-scale large scale horticultural and flowering companies. But the new model is set to bring the technology to urban and peri-urban users with some space to farm. "We found the need to tap the technology to help small-scale farmers," said Paul Kahiga an Agricultural Engineer at KARI.

The country's recent history of drastic climate changes, from drought to downpour, also drove the initiative to ensure farming continues in spite of the weather.



The more expensive and longer lasting small-scale metallic greenhouse mirrors the commercial ones and measures 8 by 15 metres, while the greenhouse made from locally sourced materials, including wood, net and polythene, measures 6 by 15 metres, but will only last for 4 or 5 years.

In an 8 by 15 metres greenhouse, a farmer can plant approximately 600 tomato plants. Kahiga advises planting high value crops like Anna F1, money Maker, Marglobe tomato species, lettuce, cucumbers and the pepper dubbed “pilipili hoho”.

The controlled climate in the greenhouses delivers high yield and uniform maturity, with over 90 percent of yield guaranteed year round according to a Horticultural Development Authority report.

In rainy or cold seasons, crops grown in the open are vulnerable to destruction and pest attacks, leading to low yields for tomatoes, which can yield can be less than 10kg per plant in a whole season. However those grown in greenhouses like Anna F1 or Money Maker a farmer can harvest in a single plant 15kg to 20kg in the first harvest and by the time the plant completes its roughly one year full cycle it could have yielded 60kgs.

With the right conditions, maturity is also shorter. Greenhouse tomatoes can mature in two months while the minimum time taken for those farmed outdoors is three months. The

quality of the crop after picking is better too, with greenhouse tomatoes enjoying 21 shelf life days compared to 14 for those grown in the open.

Depending on the demand in the market, a farmer can make from Sh.40 a kilogram for the Anna F1 tomato variety. This minimum would see the investment in the greenhouse paid for within 8 months.



When installing the greenhouses, they are built parallel to the wind direction to ensure plants inside are not ruined by rough winds. The outside has a translucent roll up polythene and the inside is padded with a net. The net, wards off pests or birds that can destroy the crop.

Experts advise that temperatures in the greenhouses range from 21 to 29 degrees, ideal for tropical crops. To regulate the temperature to that range the polythene is either rolled up when it's too hot, or rolled down in cold spells.

But humidity must be kept under control. High humidity can lead to outbreaks of diseases and pests like germination of spores of powdery mildew, while low humidity can lead to dehydration.

For the crops growing in the greenhouse drip irrigation is recommended for watering. In addition to saving 50 percent or more of water, it's cost effective to invest in and further aids yield. Soluble fertilizers can be distributed to each crop through the drip, disease is lower because the leaves are not directly watered, and the drip makes for uniformity of growth.



The KARI-designed standard 6 by 15 metre greenhouses made from locally sourced materials costs around **Sh.46, 000** to construct. The metallic ones cost **Sh.140,000**.

The lowest costing drip irrigation kit available from the Kenya Rainwater Association (KRA) costs Sh.1,750 and can water an area of 15 to 20 metres squared. The emitters' drips have a spacing of 15cm to 30cm, connected to bucket of 20 litres.

The drip irrigation can save up to 10 times the water used in other irrigation methods.

Below are KARI contacts:

Headquarters:

Director General,
Kenya Agricultural and Livestock Research Organisation,
Location: Kaptagat Rd, Loresho Nairobi Kenya

Post Office: P.O.Box 57811,
City Square, NAIROBI, 00200, Kenya

Email: info@kalro.org

Safaricom:

0722-206-986

0722-206-988

Airtel:

0733-333-223

0733-333-224

0733-333-294

0733-333-299

0736-333-294

Fibre Lines

0709 104000-60 (Safaricom)

0730 707000-60 (Airtel)

Chapter 6

What to Grow in a Greenhouse



You can grow virtually anything in a greenhouse, but that protected space is prime real estate — with careful variety choices, you can maximize profits and produce crops that don't do well outside for you.

A greenhouse is a great asset to any vegetable plot, enabling gardeners to make the most of the sun. Even the smallest, unheated structure will allow gardeners to extend the seasons and produce good crops of a wide range of vegetables.

When to use a greenhouse to grow vegetables

A greenhouse is suitable for growing vegetables in a number of ways:

- ❖ Starting off hardy vegetable plants earlier than outdoors
- ❖ Getting earlier harvests of tender plants such as French beans

- ❖ Growing tender crops such as aubergines, cucumbers, peppers and chillies and tomatoes through the hot months
- ❖ Trying more exotic, heat-loving plants such as okra and melons
- ❖ Making use of the autumn sun to raise late salad crops, French beans and even calabrese

There is a great difference between the crops grown as starter plants and the greenhouse vegetables. Masses tend to grow vegetables and fruits in their greenhouse where they've control environment to control temperature.providing heat, extend the growing season and to protect them from frosting.

However, if you are new to gardening and planting fruits and vegetables, then you must be having good ideas what to grow. God has bestowed countless variety upon us, so how can you select which are the best vegetables to grow in the greenhouse? Simply start with easy vegetables to grow so that within a year you get hands on them, so the next season you can continue to grow even the complicated ones.

1: Leafy greens:

You must start with something that belongs to “salad family” – almost every other leafy vegetable grows in the same manner, especially when considering the bedding plants.

Other than the basic knowledge, there is some aesthetic knowledge needed as well when growing leafy vegetables. They have varying tastes and colors – they make the perfect starters and sidelines. These can be a great source of income as you can sell them to various grocery stores and even wholesalers.



2: Micro greens:

In simpler words, you can grow the lovely looking and with a mouthwatering taste Tatsoi, Beet, Peas, Choi and radish etc. they are extremely loved as sidelines and with as snacks. Once you have good knowledge, you can mix the varieties and make second-generation micro greens at your own.



3. Spinach:

It is one of the most grown greenhouse plants – if you want to enjoy the freshest and tastiest spinach, cut it from the garden and cook it immediately. It is so healthy that you can increase your intake of vitamins and minerals instantly. Most importantly, you would never face trouble with growing and maintaining this vegetable.



4: Cucumber:

You must have been grown up eating cucumber salads or even the raw pieces with salt. They taste simply wonderful – however, growing them is not that simple. You need to shrink wrap them so that their freshness can be retained after harvesting.



5. Tomatoes:

Most of the greenhouses have tomatoes in various colors and shapes – they are easy to handle specially the beefsteak varieties.



6. Peppers:

Peppers are loved all over the world – they simply make the dishes tastier. To your surprise, there is a great variety of peppers that you can easily grow in your greenhouse. They have light to intense taste and colors are mind-blowing.



7: Herbs:

You might be interested in growing vegetables indoor greenhouse – herbs are the perfect in roots and without it as well. You can enhance the tastes of your meal with basil, cilantro and watercress etc.



8: Squash and Swiss chard:

They can be enjoyed planting and eating because they come in massive variety – they can even help you earn money by selling it to end users.



9: Citrus fruits:

You can grow a number of fruits in your greenhouse – these include sweet and sour, delicious looking melons, oranges and lemons. They have the ability to sustain even the coldest weather, so enjoy your cold evenings with juicy fruits.



10: Grapes:

Many do not know that the grapes can even be grown in the greenhouse – many free greenhouse plans can highlight details for you. You have to protect them from pests and take special care of the varieties like “black ham burgh” and “Buckland Sweetwater”.



11: Strawberries:

Fill your greenhouse with tasty strawberries this season – you can grow whatever type you want. Just make sure you provide them with sufficient space and ventilation.



12: Peaches:

It is very important for a newbie to select the right kind of greenhouse fruits and veggies. For example, peaches are extremely good to grow in the greenhouses or small gardens. They are nourishing and simple to handle too.



13: Coriander/Dania:

You cannot miss out the refreshing leafy vegetable, which is perfect topping for salads and soups. You simply need to pay attention while the plant is growing, as it requires proper aeration and water.



14: Chilies:

You can even keep a corner of the greenhouse to plant chilies – it can include green chilies and red ones too. It solely depends upon the kind of flavor you would like to have.



15: Raspberries:

You can actually do a very good business by growing raspberries – supply them to cake bakers and enjoy the money. In addition, they are so tasty that you can add as many in your delicious fruit salads and please the guests too. They are also ideal to blend with milk and have it in the form to shakes.



Therefore, now you must be clear enough how to start and with what kind to vegetables and fruits to start. Greenhouse vegetable gardening is not only rewarding but also fun activity too.

Greenhouse Tomato Farming



Greenhouse tomato farming in Kenya has led to a huge increase in tomato production. Most tomato farmers in Kenya practice small scale greenhouse farming of popular greenhouse tomato varieties such as Anna F1. You can make quick money in Kenya through greenhouse cultivation of tomato.

Growing plants in a greenhouse allows for easier implementation of good agronomic practices and reduces tomato production costs. Pilipili hoho (Capsicum) and onions are the other

crops in Kenya that are commonly grown in a greenhouse. With almost all varieties, greenhouse tomato farming is more profitable than growing tomatoes outdoors.

It is easier to control the temperature inside a greenhouse and less water is used when the correct irrigation method is used. Most Kenyan farmers use drip irrigation in their greenhouses. Excess nutrients in a tomato farm will lead to excessive vegetative growth at the expense of fruit development, leading to smaller and lighter fruits, and hollow tomatoes that go bad quickly.

Farmers are advised to deliver liquid fertilizers with the drip irrigation system to avoid giving their tomatoes excess nutrients. Tomatoes are a popular vegetable and are always in high demand. Most small scale greenhouse farmers in Kenya prefer to grow tomatoes. The benefits of greenhouse tomato farming in Kenya include:

Advantages of Greenhouse Tomato Farming in Kenya



1. Minimum water wastage – drip irrigation systems that are mostly preferred in greenhouses have no surface run-off since the water is delivered directly to the root area of the plants. Water is distributed uniformly, which prevents clogging.
2. Easier to manage weeds – unlike watermelon farming in Kenya that requires a lot of space, tomatoes grown in small scale greenhouses consume less space but produce more fruits per acre. The planting of tomatoes in a concentrated space makes weeding easier. Moreover, use of drip irrigation denies weeds the water they need to thrive.
3. Easier to manage tomato diseases – the closed nature of small scale greenhouses reduces the risk of soil-borne tomato diseases. These diseases spread when wet soil is splashed onto tomato leaves while it rains (or when using overhead irrigation systems). Drip

irrigation reduces the amount of moisture on the tomato leaves, further reducing the risk of fungal tomato diseases that thrive on wet foliage. Pest control is also easier in a greenhouse than with outdoors tomato farming. Birds are a huge nuisance for outdoor tomato farmers: beat them by adopting greenhouse tomato farming in Kenya.

4. Less labor – delivering liquid fertilizers in irrigation water is one form of automation that drastically reduces labor requirements in a greenhouse. Good space utilization in small scale greenhouse farming means there is less distance to cover when tending to your tomatoes. Tomatoes need staking to support the weight of the fruits and to grow upright. It is easier to stake your tomatoes with greenhouse tomato farming in Kenya.
5. Less theft – Tomatoes planted through greenhouse tomato farming in Kenya are well hidden from view. Would-be thieves can not know when the tomatoes are ripe and ready for harvesting. Stealing of farm produce is a big problem in some regions in Kenya, especially in the Central region.
6. Out-of-season Production and big profits – farmers who plant tomatoes in a greenhouse are not bound to the natural rainfall patterns. They supply tomatoes to the market throughout the year especially when there is a weather-induced drop in tomato production. This is when tomatoes fetch the best prices and bring in the most profit. Since we don't have a winter in Kenya, the only critical element needed for a year-long tomato production in Kenya is water. Temperatures are favorable for tomatoes almost all year long. The cold season lasts for only 3 months and is easily overcome by the warmer environment inside a greenhouse. In contrast, greenhouse tomato farmers in countries such as U.S. and Canada incur extra heating and lighting costs during winter.

Tomatoes grown under greenhouse tomato farming in Kenya are better protected from strong wind, strong sun, hail and changes in humidity levels. High yielding tomato varieties in Kenya such as Anna F1 tomato perform best in a greenhouse. Plant resistant tomato varieties such as the Prostar F1 by Kenya Seed Company. Use greenhouse tomato farming in Kenya to increase yields, grow tomatoes all year and increase tomato farming profit.

Growing Greenhouse Cucumbers



If you want to produce the best crop of cucumbers possible then you can't do better than buying a good quality greenhouse-specific cultivars and growing them in a greenhouse. Greenhouse-specific cucumber cultivars produce long, smooth fruits similar to those that you find in the supermarkets, but with two marked differences. Both the texture and the flavour will be far superior.

Growing Cucumbers from seeds



To begin with, sow cucumber seed on their sides at a depth of ½ inch in 3 inch pots containing a good quality, free-draining compost such as John Innes 'Seed and Cutting'. Gently water, then place the pots in a propagator or seal them inside a plastic bag at a temperature of 20 degrees Celsius until they germinate. You can expect to see the seedlings emerge in about 7-10 days.

Once they have germinated the seedlings can come out of the propagator/sealed bag and can be moved to a bright windowsill, but not in direct sunlight as the leaves can scorch. At this point try to maintain a minimum temperature of 15 degrees Celsius, and keep the compost on the moist side however avoid water-logging as this will easily kill the roots.

Once the young plants are large enough to be transplanted they can be moved to their final position, be it a grow bag or in the soil of the greenhouse. Try to avoid disturbing the roots at this point as the Cucumbers plants can go into shock (known as root-shock) and may take a couple of weeks before they start growing again.

In the greenhouse



Pot grown cucumbers will need to be planted in a warm, humid greenhouse that is kept at a temperature of at least 15 degrees Celsius. Plant them at a spacing of 2 plants per grow bag or 18 inches apart if they are being grown directly into the soil.

As before, cucumber will need protection from direct sun to prevent scorching and this can be achieved by providing shading either as lengths of material or as a 'paint' applied directly to the glass. Keep the conditions humid by regularly spraying or damping down the pathways.

Male flowers will need to be removed as soon as you see them to prevent the plants energy from being directly away from fruit production. Female cucumber flowers are easily

distinguished from male flowers as they have a swollen bulge between the bottom of the flower and the flower stem which will look like a miniature cucumber.

Male flowers will just have a plain stalk. To make life easier you can always purchase 'all female' F1 hybrid varieties which will only produce female flowers.

Cucumber Harvest



Keep the plants well watered to help them establish and to increase crop yields. Cucumber plants will need to be fed with a high potash feed every two weeks once the fruits begin to develop. You can further improve yield by encouraging your plants to climb upwards.

Train the main shoots onto 6 ft canes or strings until they reach the top of their support. At this point pinch out the growing point at the top of the plant. Once the cucumber fruit begins to develop, pinch out the end of each side shoots, leaving two leaves after each fruit. This will help to encourage more sides-hoots which in turn will produce a bigger crop of cucumbers.

You should be able to harvest your first crop of cucumbers approximately 12 weeks after they were sown. They should be picked first thing in the morning when temperatures remain cool.

Cut the fruits from the stem using a sharp blade. Timing is important as it is best to pick cucumbers while they are young and tender, and before they show signs of producing seeds. This is because older fruits can become bitter, and a mouth full of seeds can make eating it unpalatable.

If you continue to harvest your cucumber regularly then you can expect them to crop well in the greenhouse if temperatures remain warm enough.

Capsicums/Pilipili Hoho Farming in Greenhouse



Capsicum, or sweet peppers, are most productive when grown in a greenhouse, but they can be grown successfully outside in a sheltered sunny spot if the weather is good.

People around the world grow the same crop in different ways. I asked Peter to share about how he grows peppers in his hobby greenhouse in Kenya. I hope you find what he writes as fascinating as I do!

I am from Kenya's central province near Mt Kenya's cold regions with temperatures ranging from 10° to 28° (50°F to 82°F) in cold and hot weather conditions, respectively. I have indulged in farming activities ever since I was 10.

Recently, I started small scale farming greenhouse tomatoes, rabbits, chickens, guinea pigs, mushrooms (oyster), fruit, and sweet pepper. I consider farming to be one of my hobbies. I wish to share with you some of what I've learned in indoor sweet pepper farming.



Sweet pepper/bell pepper (also called capsicum) is commonly referred to as “pilipili-hoho” in Kenya. Scientifically, they are *Capsicum annuum*. This fruit is 10cm (4 inches) to 12.5cm (5 inches) and grows on a hardy bushy plant which is 60 cm (24 inches) to 90 cm (36 inches) tall, 45cm (18 inches) to 60cm (24 inches) wide.

Capsicum fruit can be yellow, orange, red or green in color. Although they may be colored distinctly, they all ripen from a green colour meaning the non-green fruits stay longer on the plant for them to acquire their particular hue. While they may be culturally similar, they are nutritionally different.

Green peppers feature an abundance of chlorophyll. Yellow peppers have more of the lutein and zeaxanthin carotenoids. Orange peppers have more alpha-, beta-, and gamma-carotene. Red peppers have more lycopene and astaxanthin, two other important carotenoids.

Due to the differences in the ripening duration (which also translates into higher nutritional value), the colored capsicums are more expensive than green ones.



The Actual Work

I do small scale farming of capsicum in a polythene (plastic film) greenhouse. I grow the Admiral F1 hybrid from Syngenta. Admiral F1 first produces green fruit, which ripen to yellow and orange when grown in the greenhouse (unlike in open fields, where it typically yields only green fruit).

In the greenhouse, these peppers are better in productivity, quality and in pest and disease control. Moreover, green house farming is much more advisable to employ in cold regions as capsicum does well in temperature ranges of 15°C-25°C (59°F-77°F).

I first germinate capsicum seeds in a nursery bed. You can make sunken or raised nurseries though I prefer sunken nurseries because they retain water more than raised nurseries.

The nursery bed has to be amply applied with manure, where I fetch aged rabbit droppings. When totally dry, I mix them well with the top soil. It is usually good to mix with cow and goat manure. Adding manure to the nursery ensures a strong and healthy seedling hence a healthy capsicum when transplanted.

After sowing the seeds, it will take about 2-3 weeks for them to germinate. In a capsicum nursery, the distance between the rows is about 1.5 inches. This will help leave enough space for watering and spraying. Capsicums will be ready for transplanting within 6 weeks.

I transplant them when they attain at least 4 true leaves. A few days before transplanting, I harden the capsicum seedlings by reducing frequency of watering gradually. On the day of transplanting, I wet the nursery enough to wet the soil and allow easy uprooting of the capsicum seedling from the nursery without damaging the roots.



Usually I transplant on to an irrigated ground in fertile loamy soil with a spacing of 75cm (30 inches) by 45cm (18 inches). In general sweet pepper seeds take three weeks to germinate, 45 days in the nursery and 90 days to mature.

Plant Enrichment

I apply diluted rabbit urine organic fertilizer from time to time to the leaves which serves as foliar feed. This fertilizer is easily made. Rabbit's urine is put into a 25 liter jerry can mixed with 500 ml drops of sugar fluid, 240 ml of EM4 (bacterial decomposition), and one liter of water of thick rice washing.

This mixture, when well fermented for about three weeks, is not smelly. It actually smells like wine and is black in color. For fertilizer application to crops, the ratio is 1:10, i.e. 1 liter fertilizer mixed with 10 liters of water. The fertilizer is rich in nitrogen, phosphorus, potassium and calcium.

Rabbits provide nutrients for the greenhouse crop.

These components boost the plant growth through improved soil structure, nutrients and organic matter as well as maintaining a good number of microbes in the soil. It also reduces pest and plant diseases. But more importantly than that, it is environmentally friendly fertilizer and in line with the spirit of the present world that is going green. I also apply anti-fungal solution as capsicum is prone to frost attacks which eventually may result to late/early bright.

I will apply pest control chemicals which kill thrips which may attack flowers, spider mites which feed on the leaf matter and white flies. Enrichment is employed after a fortnight.

Small vs. Large Scale Production

Large scale and small scale production of capsicum depends on the size of the greenhouse or land cultivated in case of open field farming. The main difference between small scale and large scale in growing capsicum is the production capacities where in large scale production cost is obviously high as there is more investment in terms of capital, labor force, fertilizer and chemicals with one acre in Kenya totaling to Ksh.150,000.

Also large scale production enjoys a wider and reliable local and export market as compared to small scale. Naturally, this translates to better profit margins for large scale. In Kenya we expect 50-60 tons per acre in a 4-6 months production period on a large scale. Since each acre plot can hold up to about 1000 plants with each plant giving 10 fruits at Ksh. 10 (~11 cents) translating to Ksh.1,000,000 (\$11500) in three months!

Conclusion

Capsicum in my area grows best in loamy and heavy cracking clay soils of pH 6.0-6.5 at altitudes of 2000M (666.67 ft). The vegetable should be grown away from solanaceous (the nightshade family which includes tomatoes, eggplant and tobacco) as they share many diseases.

It does well in cold conditions of 15°C-25°C (59°F-77°F).

In hot weather conditions the greenhouse becomes too hot and has to be cooled. I cool it by semi-flooding the greenhouse to increase moisture content around the leaves. I can also place some light tree twigs on the green house roof to block direct sunlight.

Weak and bushy plants are propped up using sisal strings. The string has to rise while twisted around the stem of the plant. Pruning is usually done by plucking out the growing tip when the plant is 30cm (12 inches) high to encourage fruit setting, lateral growth and ripening.

Fertility is assured by ample application and mixing of aged animal manure. Fertile soils promise bumper harvests! In my case I apply rabbit and chicken manure. Mulching is also ideal to prevent fruit water splash and moisture loss. Pipes, jerry cans, hoes and sprayers are the basic tools that are frequently used. Plants can be grown in suiting pots or vases where land is a minimal resource.

I wish you well as you plan to farm the lucrative sweet pepper.

What Flowers Are Most Popular for Growing in Greenhouses?



One of the benefits of having a greenhouse is having the chance to produce blooming plants all year round. With the use of things like lighting and solar heating, you will be able to maintain some of the most exciting flowers that can be found and in many cases, ensure that your

garden always has some color. It will be important that you do understand that you will need to keep the temperature and water in your greenhouse regulated to ensure that your plants have the chance to thrive.

Amazon Lilies



The beautiful Amazon Lily flower can reach up to two feet in height, it offers white blossoms that will be very fragrant and help to keep your greenhouse smelling sweet.

⇒ This is a bulb that is tropical by nature and that means you will need to maintain at least 70 degrees in your greenhouse at all times to prevent killing them. In addition to this, you will find that you will have the best results when using containers to grow the Amazon lily in a container.

⇒ Of course, you will also be able to grow other species of lilies in the process. Just make sure that you avoid over watering any of the species of lilies you feature in your greenhouse and that you offer them at least 8 hours of light daily, ensuring that you fill most of this time with natural sunlight when it is possible. This will help to keep them healthy and happy.

African Violets



Anyone looking for a flower that can offer a spray of colors will want to note that African violets can be ideal in your greenhouse.

⇒ You will need to ensure, that you use only low nutrient soil and have a high humidity level, to achieve the best possible results.

⇒ A good idea will be to pick up a growing bench and then allow the violets to have a place to grow and thrive when possible.

⇒ Just make sure that you avoid getting the leaves wet as this can change their appearance.

⇒ A trick that you might want to use when you get a plant you like is to take some leaf cuttings as a way to grow a new plant.

⇒ Unlike other flowers, these plants are reproduced in this manner, rather than a seed that uses a gestation period.

Chenille Plants



While some people are going to be seeking out actual flowers, others will want to consider shrubs and bushes, that they can use to fill their greenhouse.

⇒ One of the choices you will have is the Chenille Plant. This beautiful bush can reach six feet tall and have long cattail flowers that are bright red.

Chinese Hibiscus



While the hibiscus can have an absolutely stunning appearance, you will need to ensure that you are doing all you can, to maintain the temperature in your greenhouse, if you plan on planting them.

⇒ The reason is that sudden drops in temperature can cause them to die quickly.

⇒ The Chinese hibiscus will come in a variety of colors like orange, yellow, red, pink, white and more.

⇒ These blooms will reach up to 4 inches across and will perk up your greenhouse for a day.

⇒ However, the flowers on the plant will usually last just 24 hours before they wilt and die.

⇒ A good idea will be to use a nutrient rich soil to get the best possible blossoms and ensure that you water the plant regularly.

Roses



Probably one of the most common types of flowers you will find in the greenhouse will be roses.

⇒ The reason is that these plants don't typically do well in colder weather.

⇒ Because of the cold, rose farmers will house them in units that maintain a steady temperature of anywhere between 70 and 80 degrees.

⇒ Just note that a full day of sunlight is required, for these flowers or at least a bulb, that can simulate the rays for your roses.

⇒ With that, you will also note that the roses you can find are going to come in a variety of styles and each will have its own planting needs.

⇒ A good idea will be to talk to the local nursery to ensure that you know, what you will need to do, to keep these flowers healthy and happy.

⇒ One thing will be ensuring, that you regularly feed them food, that is designed to enhance the flowers that they will produce.

Orchids



Orchids are probably the most sensitive flowers you will find. Not only can they not handle weather that is too cold, but they can also die quickly in moderately warmer weather. This

is one of the reasons why most are grown in greenhouses. The reason is that the temperature requirements can be maintained and enough light for them can still come through.

⇒ For these flowers, you will want to ensure that you are keeping them at no less than 70 degrees, with a maximum temperature of 80 degrees. At night, you will need to ensure you are dropping the temperature to between 50 and 60 degrees to continue their stimulation.

⇒ By doing all this, you are going to find that you can, successfully, grow an orchid and end up with a plant that does extremely well. You should take note that these plants, will often thrive best in more humid conditions, so you may want to consider this when you are looking at the things you can do to produce the best blooms.

There is no doubt that with a little effort on your part, you can successfully grow some of the most popular flowers in your greenhouse.

Just make sure you focus on lighting, soil needs and proper watering to care for these flowers, and you shouldn't have any problems with them. There is nothing quite like knowing you have a high quality flower to cherish, that you have taken extra care to properly grow based on all the requirements that it will have. In fact, some of the harder to maintain flowers will give you the chance to master your skills and benefit with a beautiful reward.

Chapter 7

Best greenhouse management skills and crop protection



To have a greenhouse would mean to have something that will keep the plants growing all year-round. A good hobby that some individuals have taken in the spare time is gardening and the same thing can be done if one decides to have a greenhouse. Greenhouses are garden structures designed to cultivate plants by harnessing the heat generated by the electromagnetic radiation coming from the sun.

Greenhouses protect crops from too much heat or cold, shield plants from dust storms and blizzards, and help to keep out pests. If you will be using the greenhouse for beginning transplants or that you will be growing plants till they mature, your greenhouse should be put up in an area with the highest sun exposure. Greenhouse kits use mainly plastics that provide excellent insulation and at the same time unbreakable. The management of a greenhouse can also determine the amount of heat stored.

Benefits:

Greenhouses can be used to effectively farm various plants such as flowers, fruits and even vegetables within its controlled environment wherein humidity, condensation and light are the key factors that contribute to its effectiveness. Quality crops can be harvested if one knows how to get around the nutritional requirements of the crops.

Some equipments for greenhouse;

It is better to have cooler systems and humidifying systems to maintain a balanced temperature inside the greenhouse. To ensure that the plants are at the right temperature, a thermometer must also be installed inside the greenhouse. Panels make up the other half of the greenhouse since it controls the amount of UV light that enter.

Tips for management of a greenhouse garden:

1. When choosing a greenhouse, select a greenhouse style that matches the design of your home and the layout of your garden.
2. The greenhouse should also use the ideal kind of flowers that will survive the climate.
3. The use of heaters in greenhouses allows the farmer to plant almost anything even during the coldest times of year.
4. Before choosing and buying a greenhouse kit, it is important to consider a number of factors in order to be able to select the ideal kit.
5. If the person doesn't have an idea where to start, one can look at how the other people who do this as a hobby in the neighborhood/other counties do it.

Water: Supply and Sources

Water Supply

Water is a major factor in successful production of greenhouse plants. An adequate water supply is needed for irrigation, pesticide application, evaporative cooling (if applicable), growing media preparation and clean-up.

Plants require an adequate supply of moisture for optimum growth which is affected by many variables. The amount of water needed depends on the area to be watered, crops grown, weather conditions time of year and the environment control system. The design for the water supply needs to be made for the peak use time of the year.

A rule of thumb is to have available 0.3 to 0.4 gallons/square foot of growing area per day as a peak use rate for the warmest day. For example a 30' x 100' greenhouse with 2400 square feet of benches would require a peak use rate of 720 to 960 gallons/day. The following factors can increase or decrease the amount of water needed:

- ❖ **Solar radiation.** The level of radiation that reaches the plants is reduced by 10% to 40% due to the glazing and the structural members in the greenhouse. This reduces the transpiration.
- ❖ **Shading.** The use of shading outside or inside will reduce the radiation level on the plants. Depending on the level of shade, this will reduce evapotranspiration and therefore water needs.
- ❖ **Air movement.** Fan ventilation and HAF systems increase the rate of evapotranspiration. Depending on location and nearby greenhouses or other buildings, sidewall vents and open-roof designs can also have an influence. A 5 miles/hour breeze can increase evapotranspiration by 20%.
- ❖ **Type and size of the plants.** Seedlings or small potted plants require less water than a full-grown tomato or cucumber crop. A large root mass or heavy leaf canopy will increase water needs.
- ❖ **Type of irrigation system.** Only 20% of the irrigation water applied with an overhead sprinkler system may reach the soil in a potted plant crop with a large foliar canopy. In-pot drips systems are much more efficient as all the water applied with an in-pot drip

system gets to the soil. Subirrigation systems such as ebb and flood systems, flooded floors and hydroponics conserve water by recycling and reusing the excess water.

- ❖ **Leaching.** Traditionally, the recommendation that at least 10% of the water applied be allowed to leach out to remove excess fertilizer salts increases water usage. Often leaching accounts for a much higher percentage and can increase water needs significantly. The type of growing mix used also affects the amount of water holding capacity and therefore the frequency of watering.

Extending a limited water supply

Water supplies can be extended by several methods. Most common is adapting low usage irrigation systems. Zoning, applying the water to one area or section of plants at a time, will allow a low flow water source to irrigate a larger number of plants. Zones can be sized to utilize the flow from a well or municipal source so that irrigation takes place all day long.

Low flow wells can be set up to be pumped to a storage tank over a many hours. Water from the tank is then used to irrigate plants during the daylight hours.

Collection of rainwater to supplement a well or surface system is also possible. This works best with a gutter-connected greenhouse where the water from the downspouts is piped to an above ground or below ground storage tank.

From a conservation standpoint, keeping the piping system in good repair is important. A leak of one drop per second wastes over 113 gallons of water per month.

Water Sources

Characteristics of irrigation water that define its quality vary with the source of the water.

There are regional differences in water characteristics, based mainly on geology and climate. There may also be great differences in the quality of water available on a local level

depending on whether the source is from above ground (rivers and ponds) or from groundwater aquifers with varying geology, and whether the water has been chemically treated.

Municipal/county system water and deep wells generally provide the best water source for greenhouse operations. Chemical treatment of water may be required when pollutants such as iron, sodium, dissolved calcium and magnesium or bicarbonates are present. Surface water such as ponds and streams may have more particulate matter such as suspended soil particles, leaves algae or weeds that needs to be filtered out.

A sample of a potential water supply should be sent to an irrigation water testing laboratory for analysis.

The main sources for irrigation water are groundwater from wells, surface water, drainage ponds, rain and municipal/county water.

Drilled wells are a clean source of water for many greenhouse operations however, the water yield from drilled wells is usually limited.

Groundwater is found in aquifers that are located below the earth surface. As rainfall occurs, some of it evaporates, some of it is removed by plant transpiration and the remaining water filters down through the topsoil and flows into sand, gravel and fractured rock. It reaches a depth where all the pore spaces are filled. This saturated zone is call the aquifer.



The flow of water from a well depends on the permeability and size of the aquifer, its recharge area and the amount of rainfall. A well in one location may provide a very low yield, while another area, may provide a high water yield. In most areas, well drillers keep an accurate record of the depth and yield of wells they drill. Groundwater quality varies due to the parent material.

Even for one site, the location and depth of the well can have an important effect on water quality. Elemental content and bicarbonate levels can also change with the seasons of the year, and the amount of pumping from the wells.

Surface water includes streams, rivers, lakes and ponds which are dependent on runoff from adjacent land or from groundwater springs. These are dependent on rainfall rates that vary from year to year.

Surface water is subject to contamination from sources such as sediment, chemicals and plant growth. High levels of particles can reduce the life of pumps and clog irrigation systems and multiple filters may be required. It is also possible that surface waters can become contaminated with road salt, industrial, agricultural chemicals, algae and plant pathogens.

Drainage ponds are usually a combination of rain water and run-off. Drainage ponds commonly contain fertilizers or other agricultural chemicals. Because of the size and lack of aeration, biological conditions such as algal growth may be a concern.

Rain water can be collected from greenhouses or building roofs without contacting the ground and held in a concrete cistern, fiberglass or polyethylene tank, water silo or other holding tank. It is clean except for any debris that gets into the system.



Rain water will be very low in elemental or chemical contamination unless there is industrial air pollution or fallout on the roofs. The pH of collected rain may be low (4.0 – 5.0) but is not considered detrimental to crops because it is not buffered (does not resist change in pH) and changes readily. Rain water is an excellent and underutilized source of irrigation water.

A 1” rainfall on an acre of greenhouse amounts to 27,100 gallons. A common yield is about 65% with losses due to evaporation, wind, leakage of piping system and diversion of the first few minutes of the rainfall to remove debris. To calculate the quantity in gallons that can be collected, multiply the square feet of greenhouse building floor (footprint) by 0.4.

A basic system consists of a storage tank, roof washer, inflow pipes, overflow pipes and a diverter to redirect the excess water when the tank is full. Concrete or plastic tanks can be used but are usually limited to about 15,000 gallons. Corrugated steel tanks can be built to almost any capacity as they are delivered in preformed panels and assembled on site.

Before the water is collected for irrigation, a device called a roof washer is normally used to divert the first flush of water that is collected to remove debris from the water. Also an overflow is needed to handle excess water. The excess water is diverted to a drainage area where it will not flood neighboring property.

Once rainwater is collected, it can be distributed to the greenhouses through the normal irrigation system.

Municipal water includes water supplied by city, county or municipality. Either, ground, rain, and/or surface water may be used. The cost and quality are typically high since much of the water is for residential use and drinking water and is treated. The key concerns are whether supply is guaranteed in times of shortages and what water treatment procedures are used that may influence plant growth. Municipal water may have fluoride and/or chlorine added at rates which is not a problem for most crops. Occasionally, sodium compounds are added to treat hard water.

Protecting Groundwater from Contamination

Protect Your Water Supply:

One of the areas most sensitive to contamination is the immediate source of water which enters your operation. This may be the private wellhead or the water line(s) which carry public water. Wells provide a direct entry point for pollutants to the groundwater. Pesticide and fertilizer mixing and storage should take place away from the wellhead to reduce the chance of contamination.

This is particularly important for shallow wells and those in sandy soils. Most liquid pesticide labels now contain a chemigation provision that details system requirements. See sections on “Fertilizer Storage and Handling” and “Pesticide Storage and Handling”.

Backflow Preventers:

All potable water must be protected against backflow to ensure that contaminated water is not mixed with that used for human consumption. Backflow or back-siphoning occurs when a negative pressure develops in the water supply line, causing water that has been contaminated to be drawn back into the supply lines.

The National Plumbing Code requires that backflow preventers be installed on any supply fixture when the outlet may be submerged. Examples of this are a hose that fills a spray tank or barrel, a fertilizer injector, or an equipment wash tub. Backflow preventers should be installed when chemicals are injected into the irrigation water regardless of source.

If water is supplied by a municipal water system, check local regulations prior to installation, as some companies require a complete break in the water system. If this is the case, a separate pump and supply tanks will be required. Water lines or hoses used to fill tanks during mixing should never be immersed in the solution because back-siphoning may occur.

Backflow prevention devices should be tested annually, and the date and results of the tests should be recorded and saved.

Water Analysis

Many factors taken together determine the quality of water for irrigation of plants. The chemical constituents of irrigation water can affect plant growth directly through toxicity or deficiency, or indirectly by altering plant availability of nutrients.

Water Analysis

Once the source of water is identified, water to be used for irrigation should be tested by a reputable laboratory to determine the quality of the water to be used for irrigation, to aid in the choice of fertilizers for optimum plant growth, and to minimize the risk of discharging pollutants to surface or ground water.

Prior to new construction, potential irrigation water should be tested. Monthly analysis is recommended for new water sources. Existing greenhouse operations should monitor water quality at least twice a year; more frequent monitoring is needed to alter production practices in response to changes in water quality.

Collecting a Water Sample

When collecting a water sample, run the water at full flow for five minutes before collecting one pint of water in a tightly sealed plastic bottle. For best results, fill a clean 5 gallon bucket with water and submerge the sample bottle, then seal with the cap under water. Do not use metal lids. The bottle should be totally full with no air space remaining.

Testing by Laboratories

Analysis for inorganic elements should include electrical conductivity (soluble salts), pH, alkalinity, nitrate nitrogen, ammonium nitrogen, calcium, magnesium, sodium, potassium, phosphorus, zinc, copper and aluminum.

Testing water for pesticides, herbicides or fuel oil is very expensive, particularly if the contaminant is unknown.

Analysis for biological or disease organisms is not generally recommended since many plant pathogens are always present in water at some level.

A list of commercial greenhouse water testing laboratories is available at <https://www.environmental-expert.com/companies/keyword-soil-testing-1130/location-kenya>

On-Site Water Testing

Electrical conductivity and pH are two characteristics of water quality that can be tested periodically at the growing facility. This helps the grower get an indication of the consistency of the water supply and check the results of treatments to reduce pH or soluble salts.



pH meters range from inexpensive pen types to more sophisticated units. It is recommended to purchase one that can be calibrated using calibration solutions. This ensures that the meter is giving correct readings. Electrical conductivity meters are generally more expensive than pH meters. However, they are very useful for testing water quality and media fertilizer levels during crop growth.

	Target Range in ppm (parts per million) except for pH and EC (electrical conductivity)	^x Acceptable Range (in ppm except for pH and EC)
pH	5.5 to 7.0	4 to 10
EC	0.2 to 0.8 mS (milliSiemen)	0 to 1.5 mS (milliSiemen)
Sodium	0 to 20	less 50
Chloride	0 to 20	less 140
Alkalinity	40 to 160	0 to 400
Ammonia N	NA	less 10
Boron	less 0.1	less 0.5
Nitrate Nz	NA	less 75
Phosphate	NA	less 30
Potassium	NA	less 100
Magnesium	10 to 30	less 50
Calcium	25 to 75	less 150
Sulfate	0 to 40	less 100
Manganese	less 1	less 2
Iron	less 1	less 4
Boron	less 0.1	less 0.5
Copper	less 0.1	less 0.2
Zinc	less 0.5	less 0.3

Fluoride	less 0.1	less 1
Molybdenum	less 0.1	less 1

^x No expected crop damage under average environmental conditions. Higher rates of macronutrients may lead to undesired plant growth as in the case of plugs. The acceptable limits for trace elements and fluoride are dependent on medium pH. These levels may be too high for growing medium pH less than 5.8.

^y Usually depends on the volume of medium and volume of water applied. The medium pH with smaller volumes of media such as with plugs may be stable with 40 to 80 ppm while medium pH in larger pots with higher rates of fertilization may stabilize at 120 to 160 ppm.

^z NA – Not applicable

Note: Levels of NO₃ over 10 ppm may indicate a significant level of contamination and health hazard in drinking water.

Water Quality for Crop Production

Irrigation water quality is a critical factor for production of greenhouse crops. There are many factors which determine water quality. Among the most important are alkalinity, pH and soluble salts. But there are several other factors to consider, such as whether hard water salts such as calcium and magnesium or heavy metals that can clog irrigation systems or individual toxic ions are present. In order to determine this, water must be tested at a laboratory that is equipped to test water for irrigation purposes.

Poor quality water can be responsible for slow growth, poor aesthetic quality of the crop and, in some cases, can result in the gradual death of the plants. High soluble salts can directly injure roots, interfering with water and nutrient uptake. Salts can accumulate in plant leaf margins, causing burning of the edges. Water with high alkalinity can adversely affect the pH of

the growing medium, interfering with nutrient uptake and causing nutrient deficiencies which reduce plant health.

Reclaimed water, runoff water, or recycled water may require reconditioning before use for irrigation since disease organisms, soluble salts and traces of organic chemicals may be present.

Water quality should be tested to ensure it is acceptable for plant growth and to minimize the risk of discharging pollutants to surface or ground water.

Filters

Suspended solids need to be removed from water to prevent clogging of piping, valves, nozzles and emitters in an irrigation system. Suspended solids include sand, soil, leaves, organic matter, algae and weeds. Ground water, although usually clean, may contain fine particles of sand. All of these can be removed through filtration.

Before selecting a filter, a water analysis should be done. The type and quantity of solids should be determined taking in consideration seasonal changes such as algae growth or spring runoff. Other considerations include the flow rate needed to supply the irrigation system and the level of filtration needed to determine the type of filter. Screen or disk filters work well for most applications. A 200 mesh filter is usually recommended for micro-irrigation. The filter should be sized so that the flow rate is large enough to handle the peak demand.

Maintenance of a filter is important. Installing pressure gauges on both sides of the filter will indicate when it is becoming clogged. When the pressure variation between the two gauges exceeds about 10% the filter should be cleaned.

pH and Alkalinity

Alkalinity and pH are two important factors in determining the suitability of water for irrigating plants. *pH is a measure of the concentration of hydrogen ions (H^+) in water or other*

liquids. In general, water for irrigation should have a pH between 5.0 and 7.0. Water with pH below 7.0 is termed "acidic" and water with pH above 7.0 is termed "basic"; pH 7.0 is "neutral". Sometimes the term "alkaline" is used instead of "basic" and often "alkaline" is confused with "alkalinity".

Alkalinity is a measure of the water's ability to neutralize acidity. An alkalinity test measures the level of bicarbonates, carbonates, and hydroxides in water from the geologic materials of the aquifer from which the water is drawn, such as limestone and dolomite. Test results are generally expressed as "ppm of calcium carbonate (CaCO₃)". The desirable range for irrigation water is 0 to 100 ppm calcium carbonate. Levels between 30 and 60 ppm are considered optimum for most plants.

Irrigation water tests should always include **both** pH and alkalinity tests. *A pH test by itself is not an indication of alkalinity.* Water with high alkalinity (i.e., high levels of bicarbonates or carbonates) often has a pH value of 7 or above, but water with high pH does not always have high alkalinity. This is important because high alkalinity exerts the most significant effects on growing medium fertility and plant nutrition.

Potential adverse effects on nutrition

In most cases irrigating with water having a "high pH" causes no problems as long as the alkalinity is low. This water will probably have little effect on growing medium pH because it has little ability to neutralize acidity. This situation is typical for many growers using municipal water.

Of greater concern is the case where water having both high pH *and* high alkalinity is used for irrigation. One reason is that the pH of the growing medium may increase significantly with time. This increase may be so large that normal lime rates must be reduced by as much as 50%. In effect the water acts as a constant and dilute solution of limestone!

The problem is most serious when plants are grown in small containers because small volumes of soil are poorly buffered to pH change. Therefore, the combination of high pH and high alkalinity is of particular concern in plug seedling trays. Trace element deficiencies such as

of iron and manganese and imbalances of calcium (Ca) and magnesium (Mg) can result from irrigating with high alkalinity water.

Effects of High pH and High Alkalinity on Pesticides

In addition to nutritional disorders of plants, water with high alkalinity can cause other problems. Bicarbonates and carbonates can clog the nozzles of pesticide sprayers and drip tube irrigation systems with obvious effects. The activity of some pesticides, floral preservatives, and growth regulators is markedly reduced by high alkalinity. When some pesticides are mixed with water they must acidify the solution to be completely effective. Additional acidifier may be needed to neutralize all of the alkalinity.

If water pH is above 7.0, and the chemical requires a lower pH, a buffering (acidifying) agent should be added to lower the pH of the water for mixing the spray. Buffering agents can be obtained from greenhouse and nursery supply companies. Buffering agents should not be used with pesticides containing fixed copper or lime such as copper sulfate, or lime sulfur. Too much buffer should not be used as it may cause the water to become too acid and phytotoxicity may result. A pH of 6.0 is satisfactory for most pesticides.

To determine if a chemical is affected by high alkalinity, carefully review the product's label.

A call to the manufacturer may be needed to find the information for some chemicals.

Adjusting Alkalinity with Acids

Many greenhouse operators inject acid (e.g., phosphoric, nitric, or sulfuric acid) into water with problematic high levels of alkalinity. Acidification of water having high pH but low alkalinity is rarely necessary. The use of acid injection should be considered very carefully for several reasons. First, it is an extra step in production which will require additional materials and equipment.

Second, acids are dangerous to handle and may damage some injectors and piping systems. Third, phosphoric or nitric acid are sources of P and NO₃, so the regular fertilizer program may need to be modified to take into account the addition of these nutrients. This would depend on how much acid must be used to neutralize the alkalinity and reduce pH. Fourth, sometimes acid injection causes the solubilization of normally precipitated (unavailable) forms of trace elements resulting in levels toxic to plants.

The amount of acid required to reach the desired pH (i.e., neutralize alkalinity) is determined by laboratory titration of a water sample with the appropriate acid or by a calculation procedure. Some "fine-tuning" may be needed later when actual injection is started. Acid is always added prior to the addition of fertilizer or other chemicals.

Acids have been and always will be an excellent tool for growers to exert better control of irrigation water alkalinity (mostly bicarbonates and carbonates) and growing media pH. Once the role of alkalinity is understood, the grower may consider the following practical step to control alkalinity using acids through an injector system.

Irrigation Systems

Greenhouse crops are irrigated by means of applying water to the media surface through drip tubes or tapes, by hand using a hose, overhead sprinklers and booms or by applying water through the bottom of the container through subirrigation, or by using a combination of these delivery systems.

Overhead sprinklers and hand watering have a tendency to "waste" water and also wet the foliage, which increases the potential for diseases and injury. Drip and subirrigation systems are the most efficient and provide greater control over the amount of water applied. Also, since the foliage does not become wet there is a reduced potential for diseases and injury.

Drip Irrigation



Drip irrigation can be a valuable tool for accurate growing medium moisture control. It also saves water and labor, and reduces the potential for groundwater pollution. Drip irrigation systems eliminate runoff of water missing the pot during overhead irrigation and the volume of water applied to the pot can be controlled.

In theory it should be possible to greatly reduce or eliminate leaching from pots by simply turning the system off as container capacity is reached. Controlling drip systems with the use of a tensiometer placed in the growing medium to sense moisture tension (level) and a small computer programmed to turn the system on or off when preset moisture tensions are reached has been shown to reduce runoff from potted chrysanthemums and poinsettias to nearly zero.



Vegetable crops when grown in ground beds, bags or pots are commonly watered with drip tapes. Tubing is placed atop the ground or container or woven through the bags.

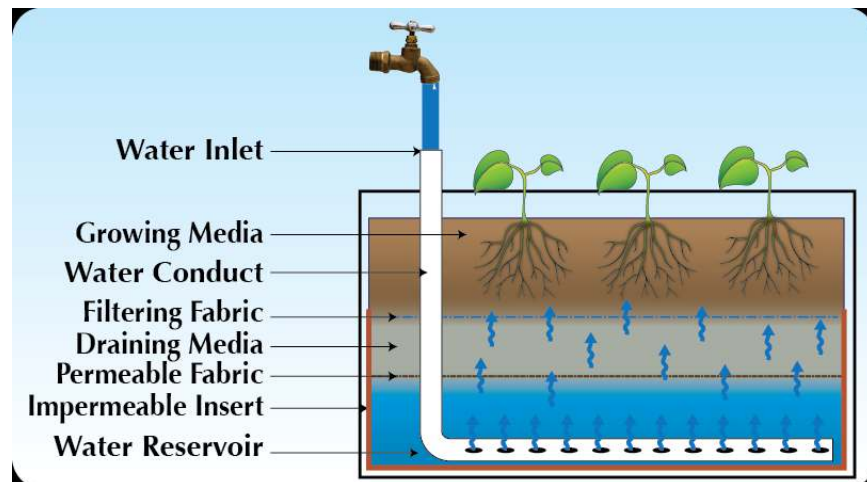
Water Trays and Saucers



In this system, water is applied to the surface and is collected under the container through collection trays or saucers. Water trays and saucers, depending on their shape and spacing on the bench, can greatly reduce runoff and leaching by containing the water draining from pots and holding the water which misses the pot during overhead watering.

They are inexpensive and reusable. Water which collects in them should be given adequate time to evaporate or be absorbed by the plant before further irrigation. Avoid tight plant spacing and poor ventilation to prevent disease problems when using this technique.

Subirrigation



Subirrigation systems, also known as zero runoff, are an environmentally responsible alternative that conserves water and fertilizers. They are being installed by greenhouse growers to improve product quality, achieve more uniform growth and increase production efficiency.

In subirrigation systems, water and nutrient solution provided at the base of the container rises by capillary action through holes in the bottom and is absorbed by the growing media. These systems are adaptable to crops grown in pots or flats.

Advantages of subirrigation systems

- ❖ Water and nutrient solutions are contained and recycled
- ❖ Water and fertilizer usage decreases at least 50% over conventional systems
- ❖ Uniform watering of all containers
- ❖ Pot size and placement can be easily changed
- ❖ More vigorous plant growth
- ❖ Foliage remains dry
- ❖ Labor input is reduced

Examples of Subirrigation Systems

1. Capillary mat systems



In a capillary mat system the pots are set on a mat that is kept constantly wet with a nutrient solution. Several styles of fabric mats are available from $\frac{1}{4}$ " to $\frac{1}{2}$ " thick. The pots take up the solution through holes in the bottom. The mat is placed on a level bench over a layer of plastic. Water is supplied from drip tubes laid on top of the fabric.

To keep algae under control, a layer of perforated film plastic is sometimes placed over the top of the mat. Algicides are also used. Some growers turn the mat over when a new crop is started. Containers holding nutrient solution and piping should be enclosed in black plastic or painted black to eliminate light and algae formation.

2. Trough system

In this system, plastic or metal troughs are placed on existing benches or supported overhead from the greenhouse structure. The troughs are installed at a slight slope (3" to 6" per 100') from one end to the other. Pots are spaced along the trough. Nutrient solution, supplied from spaghetti tubes, is pumped to the high end, flows past the base of the pots and is collected in a cross gutter at the low end. The solution returns to a storage tank under the benches or below ground to be recycled.

One advantage to this system over other ebb and flow systems is the air circulation that occurs between the troughs. Another is the ability to space the troughs for different size pots.

Trough systems tend to be less expensive than bench systems and can be easily installed in existing greenhouses.

3. Ebb and flood benches and movable trays

This system uses 4' to 6' wide watertight benches or water-tight movable trays to contain the nutrient solution. The benches, usually of plastic or fiberglass construction are installed perfectly level to maintain a uniform depth of liquid. They can be installed as either fixed or movable depending on the crops to be grown. Channels in the bottom of the bench allow the water to distribute evenly and to drain rapidly when the water supply is shut off. This allows the bench top to dry reducing algae growth and disease potential.

In operation nutrient solution is pumped from a holding tank to a level of $\frac{3}{4}$ " to 1" depth in the bench and held there for 10 minutes or long enough for the media in the container to absorb the solution. A valve is then opened and the liquid is quickly drained by gravity back into the tank. Low cost PVC pipe is used as it is not affected by the fertilizer in the water. A filter removes any solid matter. The holding tank, usually located in the floor below the benches should have a capacity for about $\frac{1}{2}$ gallon/sq ft of bench area.

The nutrient solution is used over again but adjustments in pH and soluble salts may have to be made as water is added. Water treatment with chlorine, ultra violet (UV) light or ozone is used by some growers to prevent diseases. Control of the nutrients and flow can be manual or with a controller. Watering may be once or twice a week to several times a day depending on the weather and the size of the crop.

4. Flood Floors

Flooded floors work on the same principle and with the same equipment as ebb and flow benches. A watertight concrete is necessary for the floor surface and it must be installed as smooth as possible to avoid pockets. A laser transit is used to get a perfect slope, usually $\frac{1}{4}$ " in 10'. A concrete contractor having experience with flood floor system should be hired. Berms may be installed at the post line in gutter-connected houses to create zones. PVC pipe with slots

or holes is usually installed in the floor in the center of the bay to supply and remove the nutrient solution as quickly as possible.

Large holding tanks are necessary, usually made of concrete and lined with plastic or coated with an epoxy paint. Typically a 21' x 200' bay will require 2000 to 3000 gallons of solution. In larger greenhouses, the tank has to be large enough to hold the liquid from several bays that are operated as a single zone. New flood floors can register high alkalinity as bicarbonates in the floor dissolve.

PVC piping is used to transport the nutrient solution as it is inert to fertilizers. Monitoring of the nutrient solution is done by a computer. Fertilizer is added, usually as individual elements, to maintain the desired nutrient level.

Best results are obtained if a floor heating system is installed. This provides uniform heat in the root zone area and quickly dries the floor after the solution is drained to reduce algae formation and lower disease potential. A horizontal air flow (HAF) circulation system will reduce moisture in the plant foliage. To save handling labor, a fork lift transport and spacing machine could be used.

Pest Management: Proper Use of Pesticides

- ❖ Obtain the proper training before mixing pesticides.
- ❖ Reduce infestations from outside sources and incorporate non-chemical methods such as biological, cultural and sanitation controls in your pest management program.
- ❖ Limit the frequency of treatments whenever possible, particularly nerve toxins.
- ❖ Evaluate the cost-benefit economics and use scouting and thresholds to justify treatments.
- ❖ Treat small areas as much as possible, and whenever possible, only treat infested plant(s) rather than treating all plants in the greenhouse.
- ❖ Avoid persistent compounds and slow release/encapsulated formulations. Ideally, an effective insecticide should be applied at a concentration high enough to kill all individuals in a population, and then quickly disappear from the environment.
- ❖ Avoid treatments that apply selection pressures on both larval and adult stages.

- ❖ Avoid tank mixes (mixing two or more insecticides together to control a single pest) except in cases where research has demonstrated improved efficacy.
- ❖ Rotate insecticides with different modes of action.
- ❖ Use insecticides with non-specific modes of action whenever possible. The less specific the mode of action of an insecticide, the less likely it is that genetic mutations can be selected.
- ❖ Note that resistance can develop to products other than traditional chemical pesticides. Resistance has been reported in some species to *Bacillus thuringiensis* and to some insect growth regulators.
- ❖ Test the pH of the water and adjust the pH of the water before mixing pesticides.
- ❖ Measure accurately when mixing pesticides. Measure wettable powders by weight using a scale. Measure liquids by volume.
- ❖ After mixing an insecticide with water, spray immediately or within a few hours. Never allow a mixed chemical to stand overnight before applying.
- ❖ Treat according to label directions.
- ❖ Inform your local fire department before using a smoke formulation of pesticide.
- ❖ Apply pesticides during the cooler part of the day, such as the early morning or evening.
- ❖ Add surfactants only when recommended on the pesticide label.
- ❖ Never use a sprayer for insecticides that was previously used to apply herbicides.
- ❖ Apply pesticides only after crops have been irrigated and show no signs of moisture stress.
- ❖ Do not apply pesticides with a fertilizer unless indicated on the label.
- ❖ Never use broad-leaved weed killers and brush killers around the greenhouse.

Before using pesticides, obtain the proper training.

Delaying Pesticide Resistance

To use fewer pesticides, it is important that pesticides, when used, are effective at killing pests. Pests can become resistant to pesticides making the pesticide ineffective for management. Resistance is genetic in nature, and an insect or mite cannot become resistant or acquire resistance during its life (that is, within one generation). Resistance is stimulated by widespread application of a pesticide but some individual pests survive and pass on genetic factors to the next generation.

A chemical cannot adjust in response to genetic changes in the pest population that help the pest survive the chemical application. Thus, the surviving pests can transfer the resistance factor(s) into the population, allowing the population to become resistant over a period of time. Repeat applications with one type of pesticide eventually remove almost all the susceptible individuals from a pest population and leave only those with the resistant gene.

Pests can become resistant to insecticides to which they have never been exposed. This can happen when two insecticides have a similar mode of action. Mode of Action (MoA) is how a pesticide specifically kills a pest. If two (or more) insecticides attack the pest in the same way, a resistance mechanism to one insecticide may also provide resistance to the other, even though the pest may never have been exposed to that second insecticide.

Tips for Delaying Pesticide Resistance:

- ❖ Reduce infestations from outside sources and incorporate non-chemical methods such as biological, cultural and sanitation controls in your pest management program.
- ❖ Limit the frequency of treatments whenever possible, particularly nerve toxins. Evaluate the cost-benefit economics and use scouting and thresholds to justify treatments.
- ❖ Treat small areas as much as possible, and whenever possible, only treating infested plant(s) rather than treating of all plants in the greenhouse.
- ❖ Avoid persistent compounds and slow release/encapsulated formulations. Ideally, an effective insecticide should be applied at a concentration high enough to kill all individuals in a population, and then quickly disappear from the environment.
- ❖ Avoid treatments that apply selection pressures on both larval and adult stages.
- ❖ Avoid tank mixes (mixing two or more insecticides together to control a single pest) except in cases where research has demonstrated improved efficacy. Take precautions when tank mixing. Phytotoxicity problems can occur with a mixture even though no problems were observed with either material used alone.
- ❖ Rotate insecticides with different modes of action. Unless otherwise directed on the pesticide label, switch to a pesticide with a different mode of action about every 2 to 3 pest generations or about every 2–3 weeks. Mode of Action (MoA) Classification provides information about pesticides and how they work. The actual length of an insecticide rotation depends on the time of year, as temperatures and season influence the length of insect life cycles. For example, warm temperatures often lead to overlapping generations and various stages of development present at the same time. As a result, more

frequent applications and more frequent rotations of insecticides or miticides are needed. In winter, pest development is slower and insecticides and miticides may not need to be rotated as often.

- ❖ Use insecticides with non-specific modes of action whenever possible. Most synthetic and botanical insecticides kill insects and mites by affecting very specific chemical pathways in the pest (interfere with nerve transmission, development, metabolism, digestion, etc.). The less specific the mode of action of an insecticide, the less likely it is that genetic mutations can be selected. Insecticidal soaps and horticultural oils both have broad modes of action and are, therefore, unlikely to allow for the development of resistance.
- ❖ Note that resistance can develop to products other than traditional chemical pesticides. Resistance has been reported in some species to *Bacillus thuringiensis* and to some insect growth regulators.

Improving Efficacy of Pesticides

- ❖ Test the pH of the water before mixing pesticides. Many pesticides, especially organophosphates, are not effective when mixed in water with a pH greater than 7. If necessary, use a commercially available buffering agent to adjust the pH of water to be neutral (pH 7) or slightly acidic. More information including a list of pesticides and their optimum pH ranges is available at:
http://www.umass.edu/umext/floriculture/fact_sheets/greenhouse_management/ph_pesticides.htm
- ❖ Measure accurately when mixing pesticides. Use a scale to measure wettable powders by weight. Use a measuring cup to measure liquids by volume. Read labels carefully!
- ❖ After mixing an insecticide with water, spray immediately or within a few hours. Never allow a mixed chemical to stand overnight before applying.
- ❖ Treat according to label directions. Most pesticide labels now contain information on amounts to be applied to a certain area. This is important for delivering the correct amount of active ingredient for effective control.

Preventing Pesticide Damage to Plants (Phytotoxicity)

- ❖ Apply pesticides during the cooler part of the day, such as the early morning or evening. Treatments made in the early morning allow foliage to dry before temperatures reach 85–

90°F. Take special precautions when using pesticides containing oil. Treat when conditions allow plants to dry quickly.

- ❖ Add surfactants only when recommended on the pesticide label.
- ❖ Avoid tank mixes. A mixture of insecticides may increase the chance of injury to plants.
- ❖ Never use a sprayer for insecticides that was previously used to apply herbicides.
- ❖ Apply pesticides only after crops have been irrigated and show no signs of moisture stress.
- ❖ Do not use more than one emulsifiable concentrate in a tank mixture.
- ❖ Do not apply pesticides with a fertilizer.
- ❖ Never use broad-leaved weed killers and brush killers around the greenhouse.

Disease Management

- ❖ Before growing a crop, clear the greenhouse of plant debris, weeds, flats and tools. Wash and disinfect empty benches, potting tables, storage shelves, tools and pots.
- ❖ After the greenhouse has been sanitized, avoid recontamination with pathogens. Purchase seeds, bulbs and cuttings from reliable sources. Use culture-indexed cuttings, if available, to reduce the chance of introducing pathogens. Seeds and bulbs should be disinfected by chemical and/or heat treatment, preferably by the seed company.
- ❖ Provide a hook to keep hose nozzles off the floor.
- ❖ Use horizontal air flow to minimize temperature differentials and cold spots where condensation is likely to occur.
- ❖ Use resistant cultivars whenever possible.
- ❖ At the end of each cropping cycle, discard unsold stock. Plants carried over from previous crops may harbor plant pathogens.
- ❖ Maintain a disease prevention program for stock plants. Inspect stock plants for disease and do not take cuttings from infected plants.
- ❖ During propagation, dip cutting tools in a disinfectant before moving from one stock plant to another.
- ❖ Monitor seedlings for damping off and vegetative cuttings. Look for localized symptoms such as root lesions, cutting end rot, leaf spots, and shoot blights.
- ❖ Monitor roots for root rot symptoms.
- ❖ Inspect incoming cuttings.
- ❖ Properly identify the disease.

- ❖ To prevent root rot diseases, select a well-drained medium, test for soluble salts periodically, and apply water for optimum growth of the crop.
- ❖ Space plants for good air movement and sunlight. This results in rapid drying of foliage and better spray coverage.
- ❖ Irrigate early enough in the day to allow foliage to remain dry overnight.
- ❖ Water sparingly during periods of cloudy and rainy weather.
- ❖ Learn to manipulate the greenhouse environment for disease management. Heat and vent to lower humidity in the greenhouse.
- ❖ For most foliage diseases, fungicides should be applied when disease is first evident. For valuable crops or when conditions are known to be favorable for disease development, apply fungicides on a preventive basis.
- ❖ Biofungicides are fungicides that contain living organisms such as fungi and bacteria. They must be used preventatively as they will not cure diseased plants.
- ❖ When growing in ground beds (soil of the greenhouse), treat with steam to kill disease organisms. It may be necessary to wait several weeks to allow for the dissipation or conversion of ammonium. This time also allows beneficial microorganisms to reestablish.
- ❖ To prevent the development of resistance, alternate applications among different modes of action (MoA) groups, or mix or rotate systemic/protectant fungicides.
- ❖ Use grafted tomato plants to protect against some diseases.
- ❖ Do not reuse growing media.
- ❖ When working with plants such as cleaning or propagating, work in blocks and clean hands and tools between blocks. If gloves are worn, clean or change gloves between blocks.
- ❖ Use separate greenhouses for vegetable plants and ornamental plants.

It is important to know what disease you are trying to prevent or control. When diseases are not successfully controlled or become recurring problems, it is often because the cause was not accurately identified. Considering that many fungicides have a narrow spectrum of activity, an accurate diagnosis is particularly important. Also, non-infectious diseases can mimic those caused by microorganisms. Fungicides cannot correct a problem caused by high soluble salts, poor aeration or nutrient imbalance.

Become familiar with the major diseases that affect each crop, the symptoms associated with each disease, the conditions that favor disease development and how to manage each disease. Three components are required for disease to develop: a susceptible host plant, the

pathogen and environmental conditions favorable for disease development. These three components comprise the three sides of the “disease triangle.” Aim your management practices at reducing one or more sides of the triangle, thus reducing the amount of disease.

Important principles of plant disease management include the use of resistant cultivars, sanitation, sound cultural practices and often fungicides. A holistic or integrated approach to plant disease control is the best approach and is highly encouraged.

Resistant Cultivars

A safe and low input way to manage plant diseases is to grow resistant cultivars (varieties) of a crop. If a particular disease is prevalent in your geographic area, determine if appropriate resistant cultivars are available.

Sanitation

Sanitation greatly enhances management of greenhouse diseases. Remove all diseased plants from the greenhouse. At the end of each cropping cycle, discard unsold stock. Plants carried over from previous crops may harbor plant pathogens. Inspect each lot of plants and, if disease is present, discard or treat them immediately.

Maintain a disease prevention program for stock plants. Inspect stock plants for disease and do not take cuttings from infected plants. If a knife is used to take cuttings, dip it in a disinfectant, such as a 10% household bleach solution, or commercial product for this purpose before moving from one stock plant to the next. Transport the cuttings in clean containers and work on a sanitized surface. Clean newspaper provides a relatively sanitary surface.

Before growing a crop, clear the greenhouse of plant debris, weeds, flats and tools. Wash and disinfect empty benches, potting tables, storage shelves, tools and pots to remove media and plant debris. Ventilate the area if using *sodium hypochlorite* (household bleach) for this purpose, as bleach can be toxic to some plants, especially poinsettia.

After the greenhouse has been sanitized, avoid recontamination with pathogens. Purchase seeds, bulbs and cuttings from reliable sources. Use culture-indexed cuttings, if available, to reduce the chance of introducing pathogens. Seeds and bulbs should be disinfected by chemical and/or heat treatment, preferably by the seed company.

Growing media are easily reinfested by way of dirty hose nozzles and tools. Provide a hook to keep hose nozzles off the floor. Hang up tools after cleaning them with soap and water. *Sodium hypochlorite* (household bleach) diluted at the rate of 1 part bleach (5.25%) to 9 parts water is a good general disinfectant for tools, pots and bench tops. Rinse with water after treatment to prevent corrosion of metallic surfaces. Commercial disinfectant products are available that are made for this purpose.

When working with plants such as cleaning or propagating, work in blocks and clean hands and tools between blocks. If gloves are worn, clean or change them between blocks. The same is true when working with incoming plants, always work in blocks and if possible keep plants from different suppliers separated.

Cultural Practices

Soil-borne pathogens are spread by splashing of spores and/or contaminated soil. Drip irrigation and ebb-and-flow systems help minimize splashing and pot-to-pot splashing of soil associated with hand watering. They also eliminate the use of a hose nozzle, which may periodically touch the growing medium along the bench. However, ebb-and-flow systems can become contaminated with pathogens and result in rapid and widespread infection of the crop.

Root rots caused by the fungi *Pythium* and *Phytophthora* are enhanced by high soil moisture and high soluble salts. *Rhizoctonia* is favored by a drier medium. Select a well-drained medium, test for soluble salts periodically, and apply water for optimum growth of the crop.

Use separate greenhouses for vegetable plants and ornamental plants to protect vegetable plants from tospoviruses; protect cucurbit seedlings from powdery mildew and to make it easier to treat vegetable plants if pesticides are needed.

High relative humidity is one of the major factors contributing to mildew and disease problems in the greenhouse, especially *botrytis* blight. High humidity is especially troublesome when greenhouses are tightly sealed to conserve energy. Cool nights also increase humidity. Warm air holds more moisture than cold air. During warm days the greenhouse air picks up moisture. As the air cools in the evening, the moisture-holding capacity drops until the dew point is reached and water begins to condense on surfaces.

Relative humidity can be lowered by three methods:

1. Keep the vents open an inch or so (or run exhaust fans at low capacity) when the heat comes on in the late afternoon. This allows cooler air to enter the greenhouse while warm moist air leaves. As the entering cooler air is heated, relative humidity drops. After 5 to 10 minutes, close vents or turn off fans.
2. When extremely moist conditions exist in a greenhouse, it may be necessary to exchange the air several times at night. Equipment can be purchased to turn on exhaust fans at predetermined times. The fans should remain on long enough to exhaust one volume of air. Heat loss is small, since the mass of the exhausted air is small relative to the combined mass of the greenhouse structure, plants, media, floor, etc., which hold heat inside the greenhouse. Humidity can further be reduced by watering early in the day when the warm air can absorb moisture from wet surfaces.
3. Moving air in the closed greenhouse helps reduce water on plant surfaces. A horizontal air flow system or the overhead polyethylene ventilation tube system minimizes temperature differentials and cold spots where condensation is likely to occur. The horizontal air flow (HAF) system is described below.

Overgrown plants are more prone to diseases such as *Botrytis* and make it difficult to obtain adequate fungicide coverage. Proper planting dates, plant nutrition, watering practices and height management techniques help to prevent lush, overgrown plants. Proper spacing will also lower humidity within the plant canopy.

Horizontal Air Flow

Horizontal Air Flow (HAF) is based on the principle that air moving in a coherent pattern in a building such as a greenhouse needs only enough energy to overcome turbulence and

friction losses to keep it moving. In other words, it just has to be “kicked along.” The fans need to be sized and placed properly to do this.

Air is also heavy. The air over each square foot of floor area in a typical greenhouse weighs about one pound. A 30 by 100 foot greenhouse contains about 1.5 tons of air. Once the air is moving it coasts along like an auto traveling on a level road. That is why HAF is so efficient.

It takes only four small fans to keep air moving at 50 to 100 feet/min in the above greenhouse.

Uniform Temperature

As air moves in a horizontal pattern down one side and back the other in a free-standing greenhouse or down one bay and back in an adjacent bay in a gutter-connected house, mixing occurs from side to side and floor to ceiling. Experiments instrumenting a number of houses seldom had more than 2 degrees F difference between any two points. Because of the constant movement of the air, heat supplied at one end is carried to all parts of the greenhouse quickly. Stratification is also eliminated.

Disease Prevention

Research has shown that air movement of 50–100 ft/min is adequate to keep nighttime leaf temperatures almost identical with the surrounding air. When leaf temperatures are allowed to cool much below the air temperature, the dew point is reached and condensation occurs, supporting disease organisms. Radiant cooling on clear nights, especially in non-IR poly covered houses, cools plant leaves several degrees below air temperature. HAF reduces this difference.

Carbon Dioxide

During daylight hours, photosynthesis depletes the carbon dioxide that is in the boundary layer of air next to the leaf. Moving air replaces this depleted air with fresh air having a higher carbon dioxide content. If carbon dioxide is being added, a lower level is usually adequate to get the same plant responses, for instance, 800–1000 ppm rather than 1200–1500 ppm.

Cooling Effect

During warm days, solar radiation warms exposed leaf surfaces to as much as 15 degrees F above air temperature. This can cause burning of the leaves, flowers or fruit. HAF removes this excess heat and increases plant growth. These are some of the major benefits from HAF; now let's look at some of the installation techniques.

Fan Capacity

To keep the air mass moving at the 50–100 ft/min speed, requires a certain amount of energy to overcome turbulence and friction losses. A rule of thumb based on greenhouse trials and smoke bomb tests is 2 cu ft/min fan capacity for each square foot of floor area. For example, in a 30 by 100 foot greenhouse the total cfm fan capacity needed is $30 \times 100 \times 2 = 6000$ cfm. Four 1600 cfm output fans would be needed. This can be reduced slightly in houses with plants grown only on the floor. It may need to be increased slightly in houses with crops such as tomatoes, roses or hanging baskets.

Type of Fan

Use a circulating fan, not an exhaust fan. Circulating fans operate against zero static pressure and have higher efficiencies than exhaust fans that are designed with higher static pressure to force air through louvers.



Because the fans operate 24 hours/day for 8–9 months of the year, they should be as efficient as possible. Before purchasing, compare fans on an energy efficiency rating (EER), cfm output/watt of electricity input. If the manufacturer does not provide this information you can calculate it by dividing the cfm output by amps x volts. For example, a 1/15 hp, 16 inch diameter fan has an output of 1656 cfm and uses 0.9 amps @ 115 volts. $EER = 1656 / (0.9 \times 115) = 16$ cfm/watt. Efficiencies of 14–16 are standard. Better fans have efficiencies of 18 or higher.

Generally, permanent split capacitor (PSC) motors have a higher efficiency than shaded pole motors.

Multi-speed and Variable Speed Fans

This adds considerable cost to the fan and cannot be justified for most applications, as air movement to 150 ft/min does not affect plant growth.

Home Type Circulating Fans

These low cost fans have been used by some growers with good results and by others with poor results. One grower who installed a set of these had some fail after 4 months.

Fan Location

Correct location of fans is important for smooth air flow. In free-standing greenhouses, fans should generally be located 1/4 of the width from the sidewall. This puts them in the center of the air mass that is being moved. In gutter-connected houses, where the air mass is moving down one bay and back the other, the fan should be located in the center of the bay.

In both types of houses, the first fan is best located 10 to 15 feet from one end wall. This boosts the air coming around the corner. Subsequent fans are usually located 30 to 50 feet apart with the last fan at least 50 feet from the end wall. On the opposite side or bay, use the same spacing, with the first fan located 10 to 15 ft from the opposite end wall.

Height of the fans is not critical but should be above head height to be out of the way. In many greenhouses a truss or collar tie can be used for support. Note: to keep long hair from being drawn into the fan, blades should be enclosed with an OSHA approved guard. If the house contains hanging baskets, a location a couple of feet above or below them is best.

One problem that can occur with a poor installation is short circuiting of the air across the house before it reaches the next fan. This shows up as cold spots or areas of poor growth and is caused by not adding enough energy to the air or having the fans too far apart. The easiest way to check this is to use a smoke bomb.

Place the smoke or fog behind one of the fans after the air flow has stabilized. Watch its movement. Short circuiting is easy to observe. Incense sticks also work well, especially for detecting turbulence in the air flow.

During early fall or late spring operation, the HAF system should be shut off when exhaust fans or vents are needed to cool the greenhouse. A power relay can be wired into the circuit so that either one or the other is activated at one time. Maintenance is also important for efficient operation. Clean dust and dirt from the fans to increase air flow and reduce motor temperature.

Fungicides

Too often it is assumed that disease control is synonymous with fungicide use. Fungicides can provide excellent control of some diseases, but for others they may be ineffective, unavailable or illegal. In general, use broad-spectrum fungicides (or a combination of several materials) on a preventive basis to control root diseases. For most foliage diseases, fungicides should be applied when disease is first evident. For valuable crops or when conditions are known to be favorable for disease development, apply fungicides on a preventive basis.

Thorough coverage is important. In the case of soil drenches, it may be necessary to apply additional water to push the fungicide deeper into the growing media. Most foliar fungicides act as protectants on the surface of the plant and kill spores after they germinate and absorb the toxicant. Thus it is important to have thorough coverage of the foliage before spores land on the surface. Additional applications are usually needed to protect new growth.

Biofungicides

Biofungicides are fungicides that contain living organisms such as fungi and bacteria. They must be used preventatively as they will not cure diseased plants. Biofungicides may suppress plant diseases by competition, attacking or feeding on the pathogen, or by producing secondary toxins that can inhibit the growth of pathogens.

Many different types of biofungicides are being used with variable results by growers. These variable results may be due to differences in the particular crop or plant, the soil mix used, the soil pH, the fertilizer program and the level of disease pressure.

Advantages of using biological fungicides include: lower re-entry interval (REI) than traditional fungicides, may be on the Organic Materials Review Institute (OMRI) list and may be less phytotoxic to plants.

Soil Treatment

Soil disinfection (i.e., sterilization) is an important part of soil-borne disease control when raising vegetables by the ground culture method or when soil-based potting mixes are used. Soil-borne diseases include damping-off (*Pythium* and *Rhizoctonia*), black root rot (*Thielaviopsis*), and several other root rots and wilts caused by *Fusarium* and *Phytophthora*.

Potting mixes based on compost, peat moss, vermiculite, perlite, and bark are typically pathogen-free and do not require prior sterilization. Steam treatment will also eliminate insects and weed seeds. After the soil has been treated, take care to avoid reinfestation. Soil can be fumigated with a chemical registered for that purpose. It is best, however, to avoid the use of field soil in greenhouse production of container crops.

Steam

Treatment with steam is preferred over fumigants because it is faster, very effective and safe. Proper steam treatment kills all pathogens, and nearly all weed seeds. The soil moisture content prior to steaming is important. Proper soil moisture is approximately the same as for good planting conditions: soil squeezed in the hand should crumble easily.

The temperature of the entire soil mass should be raised to 160–180°F for 30 minutes. It is important to use several accurate thermometers placed in one or more corners and the center of the soil. If it is difficult to obtain uniform steam throughout the soil, sample the soil with several thermometers to find the coolest area, wait for it to reach 160°F, and then start timing the 30-minute steam treatment.

Steaming soil can result in some undesirable effects such as overkill of beneficial soil microorganisms and accumulation of ammonium nitrogen and toxic forms of manganese. Test soil that is high in organic matter for ammonium after steaming. Several weeks may be necessary to allow for the dissipation or conversion of ammonium. This time also allows beneficial microorganisms to reestablish.

The use of aerated steam at 140–160°F reduces the undesirable effects produced by higher temperatures. In addition to being biologically efficient, aerated steam saves energy.

Causes of Plant Diseases

Bacteria

Bacteria are very small microorganisms. Under the high power (1,000 X) of a compound microscope they appear as tiny rods. To put their size into perspective, approximately 600 bacteria lined up end-to-end would measure 1/16". Bacteria can multiply very rapidly, doubling their populations every 30–60 minutes.

With few exceptions, plant pathogenic bacteria cause disease by colonizing the internal tissues of plants, thereby interrupting normal growth and function. Bacteria cause a variety of symptoms including leaf spot, bud rot, canker, vascular wilt, soft rot and galls. Symptoms caused by bacteria are often indistinguishable from those caused by fungi. Soft rot bacteria like *Erwinia chrysanthemi* invade the space between cells and dissolve the cementing material (pectin), resulting in the characteristic symptoms of soft rot. On the same host, *Pseudomonas cichorii*, which is unable to produce pectic enzymes, causes a dry lesion as opposed to a soft rot.

Bacteria that colonize the vascular system cause systemic disease. When bacteria become systemic, they are transported relatively rapidly throughout the vascular system. The plant wilts due to the plugging of the water-conducting cells. Some systemic bacteria, such as *Xanthomonas campestris pv. pelargonii*, also produce pectic enzymes that cause rot in later stages of disease.

Management Practices for Bacterial Diseases:

Copper products are very toxic to bacteria as well as many fungi. However, pesticides are only marginally effective unless coupled with sound cultural practices. Since bacteria are spread by water splash, insects, handling and pesticide applications, diseased plants should be promptly isolated from healthy plants or discarded.

Space plants adequately to allow for quick drying after watering. Discontinue overhead watering when bacterial diseases are evident. Reduce relative humidity and avoid prolonged periods of leaf wetness. When propagating geraniums, snap cuttings from the plant or, if a knife

is used, disinfest it at least when moving from one stock plant to the next. Wholesale propagators of geraniums should culture-index stock plants.

Viruses

Viruses are ultra-microscopic, infectious particles composed of nucleic acid surrounded by a protein coat. Virus particles multiply only within living host plant cells where they disrupt normal cell functions. Viruses can spread systemically throughout the host plant, and plants may be infected even when symptoms of disease are not apparent. Many different viruses can infect floricultural crops. Some, like cymbidium mosaic virus, have a narrow host range. Others, like cucumber mosaic virus and impatiens necrotic spot virus, can infect a wide variety of greenhouse plants as well as vegetable crops and weeds.

Symptoms of virus infection are most evident on foliage. Mosaic, which is a variable pattern of chlorotic and healthy tissue on the same leaf, is a common symptom. Other foliar symptoms include leaf crinkle or distortion, chlorotic streaking (especially in monocots), ringspots, line patterns and distinct yellowing of veins. Flowers of virus-infected plants may be deformed, or show streaks or flecks of abnormal petal color. A more subtle but very commonsymptom of virus disease is stunting of the plant. Symptoms may be masked under certain environmental conditions or at particular times of the year, making their diagnosis more difficult.

The spread of viruses in greenhouses occurs in a variety of ways, depending on the virus. Mechanical transmission through handling of plants or use of infested tools is an efficient means of spreading tobacco mosaic virus. However, most viruses are not easily spread in this manner. Some, such as tomato ringspot virus, can be transmitted through infected seed. The most efficient way to spread viruses in floriculture crops is by vegetative propagation of infected stock plants. In this manner, viruses are passed on through successive crops. Insects such as aphids, thrips, mites, and leafhoppers are the most important vectors of viruses.

Management Practices for Virus Diseases:

It is of primary importance to have the virus disease accurately identified. Casual on-site diagnosis is often inaccurate due to confusion of symptoms with other viruses, nutritional disorders, chemical injury, insect feeding and other problems. Serological techniques are currently available to accurately identify a wide range of viruses. Once identified, more specific control strategies can be developed.

There are no chemical control measures for virus diseases other than those directed at the vectors. Management practices include starting crops with virus-free seed or cuttings, eradicating weed hosts, reducing insect vectors and destroying diseased plants.

Some propagation specialists provide virus-indexed plant material. In the virus-indexing process, stock plants are evaluated for the presence of specific viruses through the use of indicator plants or serology and molecular techniques. Virus-indexed plants are not immune or resistant to subsequent virus infection. Proper sanitation practices are necessary to prevent virus infection. Weed control and removal of crop debris can eliminate possible reservoirs of virus infected material.

Insect control may help to inhibit the spread of certain viruses. Reduction or elimination of thrips is essential for controlling the spread of the tospoviruses INSV and TSWV (see below). Reduced handling of plants can minimize the mechanical transmission of tobacco mosaic virus. Destroy virus-infected plants.

Management Practices for Tospovirus:

Tospovirus is a virus family that includes impatiens necrotic spot virus (INSV) and tomato spotted wilt virus (TSWV). Tospoviruses, particularly INSV, are the most important viruses in the floriculture industry. These viruses are spread by the Western flower thrips. The virus is not seedborne but is brought into the greenhouse on plants that have been exposed to the virus.

Once the thrips in the greenhouse pick up the virus they can transmit it to weeds and crops. To manage tospoviruses, it is necessary to get rid of all infected plant material, eliminate thrips and eradicate all weeds. Do not grow vegetable transplants in the same greenhouse as ornamental bedding plants. Inspect plants carefully for symptoms of virus and thrips before bringing new plants into the greenhouse.

Nematodes

With a few exceptions, nematodes are not an important problem in the floriculture industry. There are several reasons for this. Soilless media are devoid of plant parasitic nematodes and subsequent contamination is not likely. Also, the relatively short length of time most crops are grown limits the ability of nematodes to build up to damaging levels.

Nematodes are small ($1/32$ – $1/4$ " long) roundworms that are common inhabitants of field soil. Most nematodes are not parasitic to plants but prey on microorganisms, insects and other nematodes. Plant parasitic nematodes are specialized to parasitize plants. Depending on the genus of nematode and the host involved, roots, stems or leaves may be colonized. With regard to root-colonizing species, root-knot nematodes (*Meloidogyne* spp.) are among the most important in outdoor crops such as herbaceous perennials.

As the common name implies, symptoms appear as galls of various sizes (up to $1/4$ " diameter) on the roots. Root-knot nematodes have a fairly wide host range that includes many greenhouse plants. The bulb and stem nematodes (*Ditylenchus* spp.) occur in hyacinth, narcissus, tulip, mountain and annual phlox and iris, as well as other plants. Colonized bulbs may display necrotic areas, and leaves may produce swellings and distorted growth. Foliar nematodes (*Aphelenchoides* spp.) occur on *Anemone*, Indian rubber plant, birds nest fern, African violet, gloxinia, Rieger begonia, chrysanthemum, *Monarda*, *Phlox subulata*, Boston fern, Easter lily, *Lamium* and *Peperomia*. Symptoms may be mistaken for those of fungal or bacterial infections.

Root-knot nematodes occur primarily as contaminants of field soil but they may also be brought in on plant material. The bulb and stem nematode may occur in field soil or as a bulb inhabitant. Foliar nematodes are brought into the greenhouse on plant material.

Management Practices for Nematodes:

Nematode problems can be avoided by using a soilless medium, purchasing plant material from a reputable source, and inspecting plants known to be commonly infected. When the bulb and stem nematode or foliar nematode appears, destroy infected plants and do not reuse media. When root-knot nematodes occur in beds, steam or fumigate the soil prior to the next crop.

Fungi

The majority of plant diseases are caused by fungi. Fungi are not plants and are distinct from plants in their inability to photosynthesize. Fungi are filamentous, highly branched microorganisms that grow over or through the substrate that provides them with nutrients. Those fungi that have evolved into plant pathogens attack living plants, and in horticultural crops, cause loss of yield or aesthetic value.

Fungi are extremely diverse in their ecology, growth habits, form and pathogenicity. Symptoms of fungal diseases are also highly variable. Fungi that survive and reproduce in the soil are termed soil-borne. They are the principal cause of damping-off, and root and crown rot.

Soil-borne fungi generally do not produce air-borne spores but are easily transported from contaminated soil to pathogen-free soil by tools, hose ends, transplants, water-splash and hands. Fungi that cause disease of stems, foliage and flowers usually produce spores that are easily disseminated by air currents, splashing water or insects.

Fungicides:

Fungicides play an important role in Integrated Pest Management (IPM). Sometimes they are the most effective component, but in other cases, their use may be ineffective, inappropriate, or illegal. To maximize the usefulness of fungicide treatments, use them in an informed and intelligent manner. An accurate diagnosis of disease (the cause of the symptoms) is necessary for the development of an effective IPM program. It is important to identify the pathogen, its host

range, know the optimum conditions for its development, and its sensitivity to specific fungicides.

A pesticide's effectiveness is not related to the number of crops on its label. Factors to consider are formulation (wetable powder, flowable, etc.), residue, spectrum of activity, resistance management, and safety. Pesticide users are responsible for making sure products are registered for use on specific crops in Massachusetts, and for using products according to label directions.

Resistance Management

It is important to use fungicides intelligently to prevent them from losing effectiveness. Resistance may result in poor or no disease control. Fungicides are classified as systemic (penetrant) or protectant (contact). Systemic Chemicals are absorbed into plant tissues.

Protectant Materials act as a barrier to fungal infection, and do not penetrate plant tissue. In addition, fungicides are grouped by their mode of action (MoA), and each MoA group is assigned a Fungicide Resistance Action Committee Group number (FRAC code). Most systemic fungicides are specific in their mode of action; thus, it requires very little genetic change in fungus populations for resistance to develop. Protectant fungicides are less likely to develop resistance problems, as they have multi-site modes of action (FRAC codes preceded by "M"). Cross resistance can also occur among members within a chemical group.

To prevent the development of resistance, alternate applications among different MoA groups, or mix or rotate systemic/protectant fungicides.

Grafting for Disease Management

Increasingly greenhouse tomato growers are using grafting to both decrease susceptibility to root diseases and to increase fruit production through increased plant vigor. Grafting involves splicing the fruit-producing shoot (called the 'scion') of a desirable cultivar onto the disease resistant rootstock from of another cultivar.

The two cultivars most widely used for rootstock in the greenhouse are ‘Maxifort’ and ‘Beaufort’. Both cultivars offer enhanced disease resistance to *Pyrenochaeta lycopersici* (Corky Root), most common species of nematodes, *Verticillium* sp, *Fusarium oxysporum* races 1 and 2, and *Fusarium oxysporum* fsp and *Radicis-lycopersici* (crown rot). In addition, ‘Maxifort’ confers a very vigorous growth habit while ‘Beaufort’ confers moderate plant vigor. For information on grafting tomatoes see the fact sheet:

Weed Management

- ❖ Develop a weed management program.
- ❖ Monitor inside and outside of greenhouses, potting and propagation areas, holding areas, and areas adjacent to these locations for the presence of weeds on a regular basis.
- ❖ When scouting, identify the type of weeds (broadleaf, or grass), life cycle (annual, biennial or perennial) and location. It is critical to remove weeds from greenhouse pots, benches and floors before they flower and produce seed.
- ❖ Keep weed seeds, and rhizomes out of the greenhouse by using sterile media, " clean " plant materials, and controlling weeds outside the greenhouse.
- ❖ Prevent weeds from going to seed in all areas of the greenhouse. Control measures include mowing outdoors, hand-pulling, and selected herbicides.
- ❖ Optimize the production cycle and minimize the duration in which perennials remain.
- ❖ Maintain weed-free areas around and between greenhouses and hoopouses.
- ❖ Use a physical barrier such as a weed block fabric helps to limit weed establishment on greenhouse floors. Leave the weed fabric bare so it can be easily swept and repair tears as they appear.
- ❖ Clean container media that has spilled or has fallen and all plant debris from container area.
- ❖ Use growing media that is weed-free.
- ❖ Use liners and transplants that are weed-free. Routinely monitor newly potted plants. Newly planted containers can be very prone to weed growth.
- ❖ Thoroughly wash containers that are going to be reused. Washing should be done in a manner that removes all leftover growing media and weed seeds.
- ❖ Use container surface covers or weed-mulch materials as container surface covers for perennials.
- ❖ To control existing weeds: 1) hand pull or 2) using a postemergence herbicide. These measures do not prevent reseeding of weeds.

Herbicides and Herbicide Applications

- ❖ Consider all characteristics of a particular herbicide when selecting an herbicide.
- ❖ Always be sure the herbicide selected is labeled for use in the greenhouse. Carefully follow all label instructions and precautions. It is the applicator's responsibility to read and follow all label directions.
- ❖ Read and understand the product labels of all herbicide products before application.
- ❖ Use a dedicated sprayer that is clearly labeled for herbicide use *only*.
- ❖ Keep accurate records of all herbicide applications on file.
- ❖ Clean herbicide application equipment after application.
- ❖ When applying herbicides outside of the greenhouse, close the greenhouse vents and openings during herbicide applications to prevent drift inside to sensitive crops.

Weed Management Inside the Greenhouse

Maintaining weed-free growing conditions is necessary to produce high quality greenhouse crops while reducing pesticide use. Insects and diseases can be kept to a minimum only if proper weed control practices are carried out regularly, along with appropriate control measures.

Weeds may compete with desirable crop plants for light, water and nutrients. Weeds are also a primary source of insects such as aphids, whiteflies, thrips, and other pests such as mites, slugs and diseases. Many common greenhouse weeds such as chickweed, oxalis, bittercress, jewelweed, dandelion and ground ivy can become infected with tospoviruses including impatiens necrotic spot virus (INSV) and tomato spotted wilt virus (TSWV) while showing few, if any visible symptoms. Thrips can then vector the virus to susceptible greenhouse crops. Weeds can also carry other plant damaging viruses that are vectored by aphids.

An integrated weed management program will help to effectively manage weed populations. This approach includes preventive measures, sanitation, physical barriers, handweeding and the selective use of postemergence herbicides.

Prevention

Weed seeds are easily blown into the greenhouse through vents and other openings. Weeds and their seeds can be brought into the greenhouse on infected plant material, tools, and equipment. Seeds can be moved in soil, by the wind, irrigation water, animals and people. Creeping wood sorrel, (*Oxalis corniculata*), hairy bitter cress (*Cardamine hirsuta*), prostrate spurge (*Euphorbia humistrata*), common chickweed (*Stellaria media*) and other weeds are persistent problems in greenhouses. These annual weeds reproduce primarily by seed, with several generations occurring per year. Prevention and sanitation are the grower's first line of defense.

Sanitation

Keep weed seeds, and rhizomes out of the greenhouse by using sterile media, "clean" plant materials, and controlling weeds outside the greenhouse. Screening vents and other openings will help to limit the entry of wind blown seed, as well as insects.

When scouting, identify the type of weeds (broadleaf, or grass), life cycle (annual, biennial or perennial) and location. It is critical to remove weeds from greenhouse pots, benches and floors before they flower and produce seed. For example, a single plant of bittercress can produce 5000 seeds, that germinate in as little as 5 days and can propel the seeds over 9 feet from the plant. Yellow woodsorrel and creeping woodsorrel also expel seeds by force throughout a greenhouse.

Physical Barriers

The use of a physical barrier such as a weed block fabric helps to limit weed establishment on greenhouse floors. Leave the weed fabric bare so it can be easily swept. Covering the weed fabric with gravel makes it difficult to remove any spilled potting media providing an ideal environment for weed growth. Regularly handpull any escaped weeds before they go to seed. Repair any tears in the weed block fabric.

Controlling Existing Weed

To control existing weeds, the following methods may be used:

- 1) hand pulling or
- 2) using a postemergence herbicide.

These measures do not prevent reseeding of weeds.

Precautions on the Use of Herbicides

Few herbicides are labeled for use in a greenhouse due to the potential for severe crop injury or death to desirable plants. This injury may occur in a number of ways including:

- 1) spray drift occurs if fans are operating at the time of application, and
- 2) volatilization (changing from a liquid to a gas).

Herbicide vapors are then easily trapped within an enclosed greenhouse and injure desirable plant foliage. Always be sure the herbicide selected is labeled for use in the greenhouse. Carefully follow all label instructions and precautions. It is the applicator's responsibility to read and follow all label directions. Use a dedicated sprayer that is clearly labeled for herbicide use *only*.

Symptoms of Herbicide Injury

Some of the symptoms of herbicide injury include discolored, thickened, or stunted leaves. Sometimes, the growing point of young seedlings is injured, severely stunting their growth. Symptoms may be similar to those caused by nutritional imbalances, viral diseases or air pollution injury. Proper diagnosis is needed to determine the causal agent. In many cases, symptoms are so severe, that the injured plants cannot be sold.

Types of Herbicides

Herbicides are generally classified according to their mechanism of action (contact or systemic) and how they are used (preemergence and postemergence) Avoid use of preemergence herbicides in the greenhouse; preemergence herbicides are applied before weeds emerge. They provide residual control of weed seedlings and can persist for many months, and in some cases, over a year. Preemergence herbicides can continue to vaporize, causing crop damage. Currently, there are no preemergence herbicides labeled for greenhouse use.

Algae Management

Algae are primitive plants lacking true roots, leaves and stems that contain chlorophyll. The greenhouse provides an ideal environment for the growth of algae. Algae growth on walkways, under benches, and in pots or plugs is a problem for many growers. Algae compete with desirable plants for nutrients and form an impermeable layer on the media surface that can interfere with water penetration.

During plug production, slower-growing plants can be especially sensitive to algae buildup. Algae are a food source for both shore flies and fungus gnats. Excessive growth on walkways can be a safety hazard to workers. Growth of algae on greenhouse coverings can also reduce light levels in the greenhouse. Prevention measures include sanitation, environmental modification, and frequent use of disinfectants.

Prevention

Sanitation

All surfaces should be kept free of plant debris and weeds that can be a nutrient source for the growth of algae. A physical weed mat barrier helps to prevent both weed and algae growth.

Environmental Modification

Proper ventilation reduces the amount of moisture in the greenhouse. Horizontal airflow fans help regulate greenhouse temperatures and reduce excess condensation. Retractable roof or open roof greenhouses provide superior ventilation benefits.

Proper Watering Practices

Overwatering crops frequently leads to algae and liverwort buildup on the surface of the growing media. Avoid overwatering crops, especially early in the crop cycle, to allow the upper surface of media to dry out between waterings. Select a growing media with the proper drainage for your crops. Water the growing containers only as needed, to prevent excess puddling on the floor.

Avoid excessive fertilization, runoff and puddling on floors, benches, and greenhouse surfaces to discourage algae growth. The use of porous concrete floors limits the development of excessive moisture in the greenhouse. The greenhouse floor should be level and drain properly to prevent pooling of water.

Disinfectants and Algicides

A number of disinfectants and algicides are registered for algae control in greenhouses. Disinfectants should be used on a routine basis as part of a precrop clean-up program and during the cropping cycle.

Liverwort Management

Liverworts (*Marchantia polymorpha*) are branching, ribbon-like plants lacking distinct roots, stems and leaves. They reproduce vegetatively and by spores. Stalked, umbrella-like structures release spores. Small, bud-like branches produced in cup-like structures on the surface of the plant also help spread liverworts from pot to pot by water droplets during irrigation. Liverworts thrive in conditions of high fertility, moisture and humidity.

Incoming plants should be inspected for signs of liverworts and isolate infested plants. If the growing media stays moist, small infestations of liverwort can quickly spread through an

entire greenhouse. Empty greenhouses should be cleaned and disinfested to remove spores. Growing media should be stored properly to prevent contamination by spores.

Avoid overwatering crops and water according to plant need. Use coarse textured mulch to reduce surface moisture levels. Topdressing with a slow release fertilizer contributes to increased fertility levels on the media surface and to the growth of liverworts. Proper plant spacing helps to reduce humidity levels. Liverworts lack true roots, so allowing the media to dry between watering helps reduce their vigor.

Weed Management Outside the Greenhouse

Managing weeds outside the greenhouse is important to:

- 1) prevent weed seeds from being blown into the greenhouse;
- 2) prevent perennial weeds such as bindweed, quackgrass, etc., from growing under the foundation of the greenhouse; and
- 3) help reduce the unwanted entry of winged insects into the greenhouse.

Prevention

Maintain a 10 to 20-foot weed free barrier around the greenhouse. A geotextile fabric can be used outside the greenhouse to prevent weed growth. Mow beyond this area to help limit the blow in of weed seeds. Or maintain a boundary of grasses, such as a mix of chewings, hard and creeping fescues. Thrips tend to not reproduce well on these grasses. Fescues are also not yet known to be hosts of tospoviruses.

Precautions on the Use of Herbicides

Herbicides may also be used outside the greenhouse. The label should state if use near greenhouses is permitted. Close the greenhouse vents and openings during herbicide applications to prevent drift inside to sensitive crops. Soil residual and post-emergence herbicides may be carefully used surrounding the greenhouse.

Herbicides should be chosen with low volatility that will control target weeds. Do not use any auxin type herbicides such as those labeled for broadleaf weed control in turf, near greenhouses. Their volatility and the extreme sensitivity of greenhouse crops to these herbicides can result in severe injury.

Flame Weeding

Flame weeding is thermal weed control that uses propane gas burners to produce a carefully controlled and directed flame that briefly passes over weeds, searing the leaves and causing the weed to wilt and die. Killing weeds can be achieved by heating without actually burning the weeds. Weeds are most susceptible to flaming when they are seedlings, 1 or 2 inches tall. Broadleaf weeds are more susceptible to lethal flaming than grasses.

Extreme care must be taken when using a flame weeder in or around a greenhouse. The most obvious concern is the chance of catching something on fire. Another, less obvious concern is the possibility that the heat may cause pollutants in the soil to volatilize.

Managing Animal Damage in Greenhouses

- ❖ Make overwintering greenhouses rodent tight.
- ❖ Mow and clean up the natural vegetation close around the greenhouses to eliminate protected areas for rodents.
- ❖ Trapping is not effective for controlling large vole populations, but can be used to control small populations. Place mouse snap traps containing bait perpendicular to the runways.
- ❖ Chemical repellents are available that can be used on plants. Some repel by giving off an offensive odor and others are taste repellents. Some of these products may not be persistent and some are easily washed off and need to be reapplied.

Small animals may occasionally invade a greenhouse and are commonly a problem in overwintering structures. They cause damage by girdling stems, and burrowing into pots if given the chance. The most likely critter to cause havoc is the meadow vole. Meadow voles construct many tunnels and surface runways with numerous burrow entrances. These surface runways are the most easily identifiable sign of voles. By the time the runways are noticed, damage is usually done.

The first step to prevent damage caused by rodents is to deny them access to greenhouses or overwintering greenhouses. Make them rodent tight by using fine mesh screen wire such as hardware cloth around the perimeter of the greenhouse. Bury it under ground and bend it outward at a 90° angle leaving it at least 6 inches deep.

Next, mow and clean up the natural vegetation close around the greenhouses to eliminate protected areas for rodents. Most of our wildlife animals will not venture across a wide-open space because they are much more vulnerable to natural predators.

Trapping is not effective for controlling large vole populations, but can be used to control small populations. Place mouse snap traps containing bait perpendicular to the runways.

Chemical repellents are available that can be used on plants. Some repel by giving off an offensive odor and others are taste repellents. These products reportedly work for a number of animal pests. Some of these products may not be persistent and some are easily washed off and need to be reapplied.

Finally, when all else fails, there are toxic baits that are effective for reducing the population. One of the most effective and common baits is zinc phosphide treated cracked corn or oats. It is a single-dose toxicant available in pelleted and grain bait formulations and as a concentrate.

Anti-coagulant baits are also effective in controlling voles. Anticoagulants are slow acting toxicants requiring from 5 to 15 days to take effect. Multiple feedings are needed for most anti-coagulants to be effective. Toxic baits can be harmful to children, pets and wildlife and should be used with utmost caution. Read and carefully follow the directions and safety precautions on the label of any of these products.

Energy

New greenhouse designs, better glazing, improved heating and ventilating equipment and new management systems should be included when upgrading or adding on. With typical annual

energy usage being 75% for heating, 15% for electricity, and 10% for vehicles, efforts and resources should be put where the greatest savings can be realized. Prices are at the time of publication.

Reduce Air Leaks

- ❖ Keep doors closed - use door closer or springs.
- ❖ Weather-strip doors, vents, and fan openings.
- ❖ Lubricate louvers frequently so that they close tightly. A partially open louver may allow several air changes per hour. Additional fuel is needed to heat this air. Shut off some fans during the winter and cover openings with insulation or plastic to reduce infiltration of air.
- ❖ Repair broken glass or holes in the plastic covering.

Double Covering

- Line sidewalls and endwalls of greenhouse inside with poly or bubble wrap to achieve the thermopane effect. Install double wall polycarbonate structured sheets to get insulation effect and reduce recovering labor.
- Use poly with an infrared inhibitor on the inner layer for 15% savings. Payback is two to three months.
- Add a single or double layer of plastic over older glasshouses to reduce infiltration and heat loss by 50%.

Site Location

- Locate new greenhouses in sheltered areas to reduce wind-induced heat loss, if this does not reduce light.
- Install windbreaks on the north and northwest sides of the greenhouse. The windbreak can be a double row of conifer trees or plastic snow fence.

Space Utilization

- Increase space utilization to 80 to 90% with peninsular or movable benches.

- Install multi-level racks for crops that don't require high light levels.
- Grow a crop of hanging baskets on overhead rails or truss-mounted conveyor system.
- Roll-out bench system can double growing space. Plants are moved outside during the day.

Efficient Heating System

- Installation of floor or under-bench heat will allow air temperature to be set 5 to 10 °F lower.
- Yearly maintenance - Check boiler, burner and backup systems to make sure they are operating at peak efficiency. Have furnaces cleaned and adjusted and an efficiency test run before heating season. A 2% increase in efficiency for a 30-foot by 150-foot greenhouse will save about 200 gallons of fuel oil.
- Clean heating pipes and other radiation surfaces frequently.
- Check accuracy of thermostats - correcting a reading that is 2 °F high will save Ksh.10,000 to Ksh.20,000.
- Install electronic thermostats or controllers with a 1 °F accuracy. Potential yearly savings of 500 gallons of fuel oil in a 30 foot by 100 foot greenhouse when changing from a mechanical to electronic thermostat or controller.
- Aspirate thermostats or sensors for more uniform temperature control. Differential between on and off can be reduced as much as 6 °F.
- Install horizontal air flow (HAF) fans to get more uniform temperature in growing area.
- Insulate distribution pipes in areas where heat is not required.
- Check and repair leaks in valves, steam traps, and pipes.

Efficient Cooling System

- Use shading to reduce the need for mechanical cooling.
- Build a new greenhouse with open-roof design to eliminate the need for fans.
- Install roll-up or guillotine sides to reduce the need for fan ventilation.
- Install evaporative cooling to get better temperature control during the summer.
- Select fans that meet AMCA standards and have a Ventilation Efficiency Ratio greater than 15.
- Use the largest diameter fan with the smallest motor that meets ventilation requirements.

- Keep doors closed when fans are operating. Locate intake louvers to give uniform cooling.

Conserve Electricity

- Have wiring system inspected for overloading, corroded parts, and faulty insulation.
- Replace 3 hp or larger motors with high efficiency ones to reduce electric consumption by 2 to 5%.
- Check for proper belt tension and alignment.
- Replace incandescent bulbs with low wattage fluorescent or HID bulbs. Save two-thirds on electricity.
- Install motion detectors to control security lights so they are not on all the time.

Trucks and Tractors

- Regularly scheduled tune-ups can save 10% on fuel usage. Keep tires properly inflated.
- Avoid lengthy idling. Idling can consume 15 to 20% of the fuel used.
- Run equipment in the proper gear for the load.

Water Systems

- Locate hot water tanks as close as possible to the largest and most frequent use. Insulate pipes.
- Heat water to the lowest temperature needed; usually 120 °F is adequate.
- Use pipe size large enough to supply necessary water at minimum friction loss.
- Eliminate water leaks. A dripping faucet at 60 drops per minute will waste 113 gallons per month.

Nursery preparation



The nursery is where the seeds are sown before transplanting or a stage of the plant before transplanting, always plant more seeds than the actual number needed to take care of germination percentage and gapping.

The nursery should be well tilted so that the seedlings have easy time germinating. Insecticide and fungicide should be sprayed to control damping off and insect cutting the seedlings. Watering and mulching should be done to help the plant grow. We have different media used in nursery and tray holders. Media can be soil, cocoa peat, peat moss among others.

Bed preparation



Bed preparation is the digging of soil and preparing where the transplant will stay till harvesting, this is done by preparing furrows at an interval of 70 cm to 30 cm on walking paths in between the beds, incorporation of organic manure or compost should be done at this stage. holes or transplants are prepared at interval and addition of fertilizer is done per hole.

Soil sterilization and potting



When the soil test has been done and found to be containing the tomato wilt pathogen, then soil treatment is essential. Treatment is done by mixing the soil with the manure and then sterilized through burning, fumigation, and steaming of the soil.

Transplanting



Transplanting of the vegetables like tomatoes always take place after 3 weeks from the nursery.

During transplanting, the nursery should be watered thoroughly to minimize plant root injury.

Transplanting of the tomato plants should be done at a spacing of inter-rows of 40 cm and into rows of 30-40 cm. Insecticide and fungicide should be applied to avoid loss of the seedlings. Watering to be done the first three weeks 3 times. 1/2 a liter per plant then twice later for 1/4 liter per plant twice a day. Transplanting results are great when done in the evening.

Top dressing



Top dressing is the adding of slow release fertilizer in small quantities at intervals to supplement the plant food. this is done 15 cm away from the plant 2 weeks after transplanting, repeating 2 weeks later, then once per month until harvesting where the rate might increase depending on the variety. After top dressing applies a good amount of water, to help the fertilizer dissolve in the soil.

DE-suckering



Suckering is the removal of suckers from the tomato plant. suckers are growth found between plant main stem and the leaves. the removal is important to maintain one stem that promote ease of management. Suckers also use a lot of tomato food hence poor fruiting. proper del suckering promote healthy fruit sets and also aeration for the tomato plants.

Staking



Staking is the support of tomato plants so that they don't fall on the ground. In the greenhouse, this is done using manila twines which limit fungal infection and are tied to the support system within the greenhouse. The twines are rolled on the tomato stem. this promotes ease in defoliation, de-suckering, and spraying.

Pruning



Pruning / defoliation is the removal of extra leaves from the plant, this is done from the bottom of the plant to the top during different stages of growth. a determining factor in defoliation is the fruit set/ trusses.

Spraying



Spraying should be done as soon as there is a disease break, or when scouting has been done and insects discovered, at greenhouse Kenya we give you a spray guide of the greenhouse and outdoor production

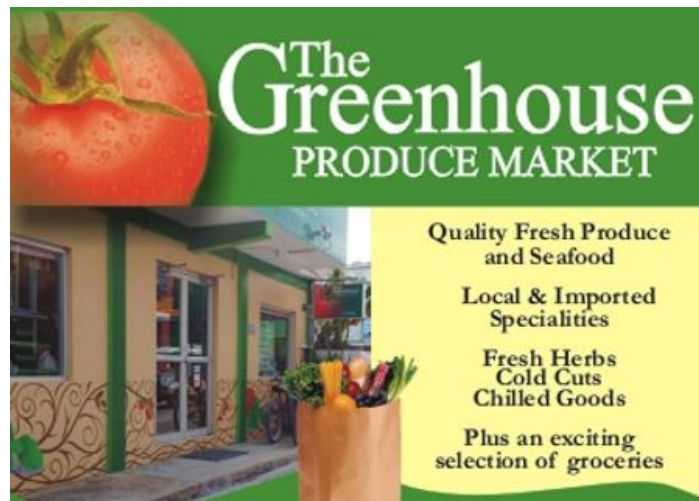
Harvesting



Harvesting of the tomatoes should be done twice a week in the greenhouse or once when the tomato has reached a breaker ten weeks from the transplanting day. The harvesting of greenhouse tomato is a continuous process that takes up to eight months of harvesting with proper management and good greenhouse variety selection.

Chapter 8

Marketing Your Greenhouse Produce



Selling a product can be an intimidating process to people who have little experience selling. The best time for your “marketing plan” to begin is before construction of your system as you research to determine what you are going to produce during your “test grow” period.

Although you can’t get it perfect the first time around, you will do a “preliminary market survey” before you do your first test grow to get a general idea what is most valuable to try out during the test grow.

After you start to get data from test grows, and take samples to potential customers to determine pricing, you will have even better information on what to grow and where to sell it. To sell everything at the best prices, you need to determine what your market (your customer) wants and needs, then deliver the perfect product to them. A good marketing plan is simply a plan for finding out what the product is, then reaching your customer and delivering that product.

Knowing your market or outlet, for the produce you will be growing and selling to, is as important as your growing facility. Who and where are your customers? Understanding your market points in the right direction of narrowing down your greenhouse location.

Let's dive a bit deeper into why you need to understand your market. Again, "market" being the buyers and community your farm will sell to and interact with. When starting a commercial greenhouse you need to grow a crop that will sell in the market. Find this out by answering:

- ❖ What do the consumers want/currently buying?
- ❖ What are the consumers not happy with from current suppliers?
- ❖ What trends are coming?
- ❖ Are there niches not being taken advantage of?
- ❖ Who are the consumers?
- ❖ Is there an area of concentration of consumers?

Research, research, research! The questions above can't be assumed or dealt with feelings if you want to really succeed. Find out what is happening in the real world, go to potential customers and talk with them. Go to grocery stores and ask the produce managers questions. What trends do they see? What product flies off the shelf? What do people ask for but don't yet have in stock?

Visit restaurants and strike up conversations with the chefs. What do they like to cook with? Is it what they really want? Could it be better or different or from a closer supplier? If you are not good at this or are nervous and know you won't go through with it find someone who you trust and have them do it. There is no Field of Dreams, people don't show up out of the blue. You have to find them, know what they want and then they have to know you are there with a product they want.



Another great way to find customers, test the market and show them the quality they will be getting from you is to grow a small crop and take it to people and businesses you think will like it and let them try it. Tell them the only thing you want in return is their honest opinion. Don't expect for them to come back to you readily offering their opinion and asking to buy product.

Continue to talk with them over time. If they mention they don't like, want, need etc. the product. Grow something different and try again. Even if that specific chef or person doesn't want to do business with you, their insight is the second best thing you can get. Find out what their customers like as well, they are the real consumer.

This brings up another part of finding your market. Part of it is made up of who will buy but also how you want to sell. There are several different ways, each with different customers and different processes of getting the product to the consumer.

Restaurants

Some restaurants buy from a wholesale company but many chefs pick and order produce from local growers when needed. This route may not be daily consistent but if you deliver on quality the chef will take notice and expand on what they buy from you. Typically you will be delivering small quantities to each location/restaurant 2-3 times a week.

Wholesale/distributor

This is the factory grower's ideal customer. The wholesaler will be looking for large quantities of a few varieties. They typically pick up from the greenhouse on a regular basis. Having one or few customers reduces headache on the distribution strategy. The downside of the wholesale buyers are, they are more price sensitive and losing a contract can be detrimental because they are responsible for a large percentage of your business.

Farmers markets

Typically these are a weekend function but more are either expanding times to include the middle of the week or separate markets focus on the middle of the week. Farmers Markets are a great way to connect with your customers and talk about their likes and wants but also you can see what other growers are selling or not able to sell.

This is a retail setting so your displays and signage will need to be well thought out and attractive. Watch people as they approach your space, see where their eyes move to and from. Use this to your advantage for product placement. Farmers markets are also the ideal place for a local grower because that is what the customers are looking for.

Schools

As with each of these markets you will need to start by asking questions and doing research. This especially applies to schools. Each school has different procedures for buying produce for their cafeterias. Best way to find out is go and ask.

Find out how they currently get produce, if they are wanting a local farm to school grower and what produce they use. Finally ask how you can become their vendor. Schools will be similar to wholesale as they will buy larger quantities at lower than retail or B2B prices, but once you have a contract it will be consistent.

Retail at the greenhouse

The toughest part of retailing from the greenhouse is getting the customers there. There is a built in draw because people like to see where the food comes from and you will get those that are interested in the process. Awareness and community involvement is huge and will be driven by your marketing.

This doesn't mean you have to only retail and be open all week. Often growers who retail at the greenhouse will be open a few days a week for just a few hours to be available to the interested people and try and move product that might not have been sold through other outlets.

Finding your market is done through a lot of research. The same goes for how you will go to market. You don't have to stick to only one outlet or participate in all of them. Figure each out and pick the one(s) that you can see yourself enjoying. You can always shift or add different markets as you grow.

Staying on top of market trends

Through the process of finding your customers and offering a product you will see a snapshot of the current market. The market, customers and their wants/needs, continuously changes and evolves. It is important to be aware of how these changes affect your business and when to shift your business to match.

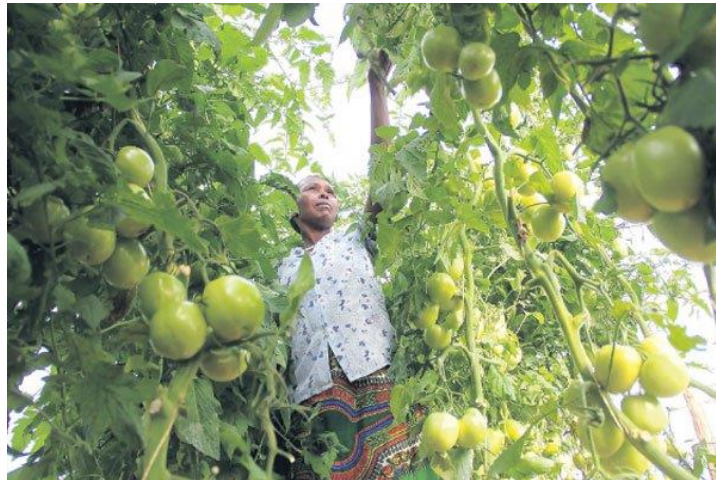
An example of this could be made with the evolution from traditional farming to organic to now an emphasis on sustainable and locally grown. Many times your growing practices may not change but your message and marketing efforts will.

Point being always keep an eye on what is happening with other growers and buyers. Movements creep up and can explode in popularity. The market never lies, it wants what it wants regardless of how you as a grower wants to function. You may not always want to follow the trends but if you do, you don't want it to be too late because closer attention wasn't paid.

When it comes to finding your market you will need to dive in and research all possibilities. Get out and talk to people who make decisions, goals being, getting customers, getting possible customers and getting a firm grasp on what the end user wants. This can't be left to assumptions or feelings.

Chapter 9

Greenhouse Farming Tips



Despite the benefits of greenhouse technology, most farmers face numerous challenges. They include:

TEMPERATURE AND HUMIDITY

Many farmers fail to get good profits from greenhouse crops because they cannot manage the two important factors that determine plant growth and productivity. Greenhouse temperatures below 13 degrees Celsius and above 30 degrees Celsius in the case of dry air or higher than 30 to 35 degrees Celsius in cases of high air humidity affect growth and productivity of most crops. The optimal temperatures for production of greenhouse tomatoes, pepper and eggplant should be 15 to 30 degrees Celsius and not beyond 35 degrees Celsius.

The temperatures should be maintained at around 16 to 30 degrees Celsius during the day and 13 to 18 degrees Celsius during the night.

Some tomato farmers close the greenhouses the whole day without ventilation resulting in excessively high temperatures beyond 40 degrees Celsius that lead to reduced performance of the crops. Generally, small-scale greenhouses are prone to overheating when the sun is too hot.

Farmers should, therefore, open the doors and sides of the greenhouse from 8am to 5pm for ventilation and close them at night to reduce heat loss. Greenhouses with only insect nets on the walls are unsuitable for areas with low temperatures like the highlands of Kericho, Mau Narok, Molo and Mt Kenya regions but may have positive effects in hot and warm areas such as Mombasa, Kitui, Kisumu, Machakos and Garissa. Ideally, farmers should have a thermometer for measuring temperature inside the greenhouse for effective management.

High relative humidity resulting from crop transpiration, water evaporation from the humid soil or other growing media and condensation of water vapour on the different greenhouse surfaces is another challenge.

Relative humidity above 80 per cent coupled with high temperatures increases incidences of bacterial and fungal diseases like bacterial wilt and botrytis (gray mold) while greenhouse conditions with relative humidity below 60 per cent and high temperatures create favourable micro-climate for rapid multiplication and development of mites and insect pests.

Humidity in the greenhouse should, therefore, be regulated by ensuring adequate ventilation, maintaining high temperatures at night, using plastic mulching on planting beds and avoid wetting of the greenhouse floor.

LOSS OF SOIL FERTILITY

This is a common problem as most farmers plant one crop continuously without rotation. This can be overcome by rotating crops, for example growing onions or melons, pepper or eggplant after tomatoes and the use of both organic and inorganic fertilisers to replenish soil fertility.

Farmers can also replace greenhouse soil by bringing quality soil from outside. Adopt the technology of growing crops in pots or soilless cultures. The soils when used continuously with same crop will have a buildup of diseases, especially bacterial wilt, bacterial canker, fusarium and verticilium wilts.

Greenhouse farmers are, therefore, encouraged to treat the soil by sterilisation, solarisation or fumigation using fumigants such as Dazomet, Metam Sodium and Chloroptin.

Greenhouses get contaminated by people visiting the structures or by use of infected planting material, water and farm tools. Have a foodbath at the entry.

LACK OF QUALITY WATER SOURCES

Many parts of the country are deficient of good water sources and rivers or boreholes may also be absent. In addition, available water could be saline, chlorinated or contaminated with diseases like bacterial wilt, hence it is of poor quality.

Contaminated water is common in areas where farmers in sources of water plant crops like potatoes, tomatoes and water flowing downstream is collected by farmers for greenhouse farming. This introduces bacterial wilt in greenhouse tomato.

PESTS AND DISEASE

Management of insect pests and diseases is the biggest challenge in greenhouse farming. This depends on the type of the crops that are planted. However, generally, pathogens and insects can be established in a greenhouse very fast. They are very difficult if not impossible to get rid of effectively. For greenhouses that are covered with plastic, the use of ultraviolet-absorbing plastics can reduce insect problems.

Dos and dont's in greenhouse farming



A worker tends to strawberries grown in pipes in a greenhouse in Kinangop.

Farmers need to know that with the ever-changing climatic patterns and every farm being different, training is crucial for any successful venture. Doubling application of some inputs to hasten the growth process is a common phenomenon. This not only stresses the crop but also causes them to fail. What's more, too much of chemicals will affect the soil.

Farmers need to understand that the technology behind quality drip irrigation systems ensures each crop gets the right and equal amount of water and nutrients.

Greenhouse farming is not a new concept in Kenya, with many farmers growing crops under the system.

However, despite increased uptake of greenhouses, many farmers, including the experienced ones, make several mistakes that lead to huge losses. Here are the common ones.

a) LACK OF TRAINING:

A good number of farmers don't believe in greenhouse agricultural training modules or those who seek training do not concentrate during sessions.

The excuse behind this is that most say that they have watched other people engage in the farming, so they can borrow lessons from them. Farmers need to know that with the ever-changing climatic patterns and every farm being different, training is crucial for any successful venture.

b) FARM MANAGEMENT:

For a crop to attain its optimal potential, it requires good care. This includes adhering to the watering regimes and schedules, feeding nutrients and controlling pests or diseases. A farmer should monitor growth of his crops or have someone to do so. Modern farming techniques have made farming an easy activity but this should not mean total neglect of the crops.

c) TECHNICAL SUPPORT AT THE FARM LEVEL:

Farmers need to understand the importance of professional input and advice. As an addition to the monthly field visits by agronomists, there are guide books that explain how to take care of crops. One can also get online support. A farmer should seek help always, even when he feels he does not need it.

d) DESIRE FOR QUICK RESULTS:

Greenhouse farming has eased field activities, however, this does not mean there will be absolutely no work to be done. The general perception that the crop will grow by itself is misleading to say the least.

In the desperate attempts to achieve even higher yields, farmers are known to distort professional advice accorded to them in search for quick money. Doubling application of some inputs to hasten the growth process is a common phenomenon. This not only stresses the crop but also causes them to fail. What's more, too much of chemicals will affect the soil.

e) PESTS AND DISEASES:

It is important to note that greenhouses decrease chances of pest attack but they do not eliminate them as some farmers believe. Greenhouse kits such as the Amiran Farmers Kit come ready with pesticides that help in controlling inevitable pests such as whiteflies. However, correct application of the chemicals is necessary.

f) SOIL TESTS OR ANALYSIS:

Some farmers skip this test without understanding that pathological analysis of the soil is crucial in greenhouse farming. Timely detection of pathogens like bacterial and fusarium wilt and nematodes will help you know what to grow and curb losses.

g) GREENHOUSE HYGIENE:

Farmers are strictly advised to limit human traffic into their greenhouses. People might carry bacteria, especially on their shoes into the facility. It is important to have a footbath at the entrance of the greenhouse structure for cleaning feet or shoes before entering the greenhouse.

The outside cover of the greenhouse should be clean and farmers should remove dust from cover to ensure enough light reaches the crops.

h) NOT EVERY PIPE WITH HOLES IS A DRIP LINE:

Farmers need to understand that the technology behind quality drip irrigation systems ensures each crop gets the right and equal amount of water and nutrients.

Netafim, the Israeli multinational firm that invented drip irrigation, insists that small-scale farmers need to invest in narrow drip pipes that ensure maximum distribution of water at minimal pressure.

In addition, the system should have valves that regulate the amount of water coming out and prevent dirt from clogging the pipes.

Drip irrigation pipes are important in greenhouse farming since they are the sources of water and soluble nutrients to the plant. The pipes should be flashed on a weekly basis.

The process is to unfold the drip line at the edge of the bed and open the water to flow through. Any debris that may have accumulated inside should be washed out. If clogging persists, farmers are advised to use Superlink, a chemical that dissolves any salts that may have built up in the pipes. Piercing the emitters using sharp objects is prohibited.

i) UNDER IRRIGATION/OVER IRRIGATION:

Greenhouse farming uses lesser water compared to the other farming methods. This, however, should not be taken to mean that you shall use no water. Whilst some farmers believe greenhouse crops do not require water from time to time, others over irrigate and flood their crops. Too much of anything is poisonous.

To check your soil for either of the two, scoop it with hand and squeeze. Over-irrigated soil will appear muddy with some water dropping while under irrigated will be dry and the plant is stressed.

j) NOT ALL SEED VARIETIES ARE SUITABLE FOR GROWING INSIDE THE GREENHOUSE:

Farmers should understand that seeds are divided into those for open field and for greenhouse farming.

k) IMPORTANCE OF NURSERY SET:

The growing media contained in the tray is porous to allow young roots to grow faster and spread easily. The media doesn't keep water, thus, decreasing the chances of disease brought about by excess water.

The nursery trays allow only for one crop per tray-hole, so the plant does not compete for nutrients. The nursery set allows production of healthy seedlings that grow fast.

Having discussed the common mistakes, here is what to do before you start greenhouse farming.

First, start with soil analysis to test for bacterial or fusarium wilt and nematodes. These three affect tomatoes and capsicum, two common crops in greenhouse farming.

Second, the land terrain of the farm should be even. In regards to size, the standard greenhouse such as the Amiran Farmers Kit fits on about an eighth of an acre. One should place the greenhouse strategically away from too much shade for best results. Farmers should also have windbreakers on the side of the greenhouse.

Third, water should be clean and reliable. Rain harvesting and wells sinking is a welcome idea in this aspect. Fourth, research on market and seasons.

Fifth, seek financial aid to invest in quality greenhouse for better results and taking an insurance cover will help you manage risks. Sixth, invest in farm workers who are well-trained on the basics of greenhouse farming.

Chapter 10

Success stories of Kenyan Farmers owning Greenhouses



Young Farmer Started-Out without Capital; Today He's Reaping Big Returns

When we were young, our teachers and relatives would often ask us “What would you like to become when you grow up?” And we would answer heartily: “A pilot” “A teacher” “The President” “A rocket scientist” or something similar to that.

But times have really changed, and those so-called “big professions” are no longer the in thing. Larry Keya is a young man who seems to have figured out this already.



He decided to become a farmer and an online tutor right after graduating from campus. I recently caught up with Mr. Larry in his small farm in Eldoret (Kenya) and managed to grab a few jewels of wisdom from him.

Why did you decide to venture into agriculture at such a young age?

Larry: Actually, the first time I ever dreamt of becoming a farmer was when I was in my second year of campus. I had big dreams, I wanted to own numerous greenhouses and start a big farming business in my home. As you would guess, I did not have any capital let alone experience and skills.

That must have been a tough start, tell me more

Larry: Just before I graduated from campus, I decided to narrow down my list of ideas to two. I resolved to start an ICT related business (I am passionate about ICT matters by the way). The IT business would help me pay my bills and raise some capital to nurture my farming dream.

Talking about ICT business, what type of business did you start?

Larry: I would repair computers sell software and for a short while, I distributed Internet to schools and offices in Eldoret town. I am still running some IT related business, on my website only that right now I am giving out tutorials on my experience and research in farming.

What challenges did you encounter starting out?

Larry: Anyone who is running a business will tell you that what is on paper rarely translates to what you get when you embark on the actual business. From struggling to find a *fundi* (carpenter) to getting conned, to getting a good farm help etc....there were so many mistakes I made.

In fact, I did not get any return on investment (ROI) from the first season; I was tempted to give up but I kept pressing on.

From your experience, what advice would you give to anyone who is following a similar path?

Larry: Prepare your mind it is not going to be an easy ride. But with the right kind of advice, mentorship and commitment, there is no reason why one shouldn't overcome whatever obstacles you find on the way.

How did you get the capital to set up all these structures in your farm? They must have cost you a lot of money?

Larry: Yes indeed, they cost me a fortune given that I had not saved more than Ksh.100,000 in my bank account. At first, I looked for a friend and we formed adhoc partnership, unfortunately he quit when we made losses during our first year.

Recently, though, I have been getting funding from Youth Development Fund, which was initiated by our government some time back.

How is your business today?

Larry: The other day I took stock of my achievements... and I now believe what they say ‘Only Dreamers are Achievers’ because I once dreamt about owning one Unit of greenhouses and now I have two.

I’m currently working on my third project. I am living proof that ‘There is a lot of value derived from starting small.’

An estimate of the cost you incur per year in your farm

Larry: After incurring the cost of building the greenhouse each year I normally spend a maximum of Ksh.20,000 to keep the greenhouse running for a full season – that is without accounting for labor. This is for a standard 8 by 15 unit.

Roughly how much do you earn from your farm per month? Is it worth the effort?

Larry: I can say it is worth it. I earn more than most of my friends who took white-collar jobs after graduating from campus.

Income is, however, dependent on what I plant. For example, if I plant cucumbers I make **Ksh.70,000+** and from Tomatoes **Ksh.90,000+** from green capsicum I make **Ksh.80,000+**.

Currently, I am testing new frontiers like planting ornamental tomatoes in a greenhouse and I am also slowly starting open field farming.

That is quite a lot of money, how do you market your farm products?

Larry: Market is one of the trickiest bits because of most farm products are highly perishable. I used to dump my produce to the main market but now I am looking into selling the produce on my own through value addition.

In fact I have been researching a lot about cucumber juice and it is something that I will definitely start doing very soon. Who knows maybe in a few years we may also be talking about how I started my cucumber juice processing plant.

What's your message to the youth who keep saying there are no jobs yet they can take to farming to create jobs rather than seek jobs?

Larry: Opportunities are always available. You just have to be open-minded enough to look and see them. When you lock your mind to the 'There are no Jobs Mentality' you will never see the opportunities around you.

Farming in itself presents one of the best opportunity to create income because everyone everyday must eat. The Key is starting small with patience and persistence

Your final thoughts

Larry: I would like to thank you for your initiative of starting Whatsapp Agribusiness groups because through your platform Kenyan youths can learn to open their minds to various agricultural opportunities available out here.

The loan that made me a thriving farmer



Peter Kanyi in his greenhouse in Kikuyu, Kiambu, where he grows capsicum.

When Peter Kanyi took a loan in 2012 from the Youth Enterprise Development Fund (YEDF) to start a farming project, he wasn't exactly sure how the venture would turn out.

Two years later, the success of the agribusiness project was recently on display at the Nairobi International Trade Fair.

Displaying the succulent capsicums was Rosemary Wangare, a marketer with Foliage Masters, the trade name for Kanyi's agricultural products. She was showcasing one of the few successful farming projects funded by the YEDF.

The story behind the capsicums on display at the fair lay elsewhere in Nderi Village, Kiambu. On the leased three-and-a-half-acres, crops thrive, turning in an average profit of Sh.20,000 a week.

It all started when Kanyi, a landscape architect, saw an advert in a newspaper inviting young people to apply for loans from the YEDF. He tried his luck.

“I was surprised when the officers from the fund came to assess my land, as well as my project proposal, and concluded that I qualified for Sh.300,000 loan, which was to be paid directly to the company that was to put up two greenhouses, complete with an irrigation system,” says the Jomo Kenyatta University of Agriculture and Technology graduate.

In the two greenhouses, he planted capsicums, which produce an average of 100.kg per week. He sells his crop to hotels, supermarkets and companies such as Fruit Juice.

But it was not easy when he started. Kanyi lost his crops to powdery mildew that swept through his greenhouse destroying the capsicums.

“I was lucky that I had diversified. The losses put me down, but I was able to pick up through sales from other crops.”

With the returns from the greenhouses, he is comfortably able to cover his overheads, service his loan at Sh.10,000 a month and keep a tidy balance.

“The biggest challenge in farming is market and knowing what is selling at what price at any given time. I’m constantly doing research and avoiding traditional outlets like open-air markets where farmers are at the mercy of traders.”

He points out that farming is capital-intensive and for him to make profit, he only goes for crops that will fetch over Sh.100 per kilo. This is not likely to happen if one is dependent on the traditional markets.

“In the open air market, you find traders buying a product at Sh.20 per kilo and re-selling it elsewhere at Sh.120. The trick is to navigate through this web of traders and middlemen to get the end of the market chain. This is why I have a full-time marketer.”

He acknowledges that there are always many variables that often come into play, and which can easily shatter a farmer’s dream. These include new diseases and market glut.

To cushion himself against this, Kanyi does not rely on one crop. He also grows carrots, cabbages, sukuma wiki (collard green) and strawberries.

BURN YOUR FINGERS

These are staggered all-the-year around. “I make sure every month I plant a little of everything. This ensures that every week throughout the year, I am selling something and I have cash coming in every week. It also makes the farm self-sustaining.”

Eventually, he plans to extend his farming to cover all the three-and-a-half-acres. One thing he has learned is that getting to the point of optimum returns is a long and painful process.

“Always start small and expand gradually. Don’t jump in expecting quick profits and remember at one time or another, you will burn your fingers. And when this happens, you must have the resolve to pick yourself up and forge ahead. In the long run, farming is rewarding.”

The 31-year-old consultant with Landscape Architects says farming comes naturally to him because his full-time job involves plants and moving the soil around.

Kanyi encourages the youth to embrace farming, pointing out that with a rapidly growing urban population, there will always be a market for food.

Why small-scale farmers reap low yields after adoption of greenhouses



Stanley Ndung'u tends to tomato plants in one of his greenhouses in Athi River.

A visit to Stanley Ndungu's one-acre farm in Athi River reveals two greenhouses occupying just about an eighth of an acre. But these seemingly 'small' structures house numerous rows of green, leafy and tall plants dotted with plum healthy-looking tomatoes.

The ground below them is brown, devoid of weeds or any other crop residue common in most gardens. As Mr Ndung'u walks round the farm, inspecting the growing vegetables, he appears relaxed and contented.

The greenhouses provide optimal conditions that boost plant yields.

“Compared to when I grew crops in the open, I no longer face major challenges of pest and diseases or dry soils devoid of moisture,” he says. Since mid-December last year, Ndung’u has been enjoying a bumper harvest of at least two crates (140 kilogrammes) of tomatoes weekly from his small piece of land.

The farmer is part of a growing agricultural community that has invested in greenhouses to cash in on horticulture produce — a major income earner.

Government statistics indicate that horticulture contributes up to 36 per cent of the country’s total agricultural gross domestic product (GDP) and grows at a rate of between 15 and 20 per cent each year. It is this attraction that has pulled the likes of Ndung’u into farming.

But while Ndung’u may be ‘laughing’ all the way to the bank, thousands of other Kenyan small-scale farmers, who blindly rushed to invest in new agricultural technologies — such as greenhouses — are not as lucky.

Despite buying greenhouses, many of them give up on the technology after incurring huge losses due to low crop yields.

Yariv Kedar, an agricultural scientist who has worked in many sub-Saharan African countries for years, says that the problem is not unique to Kenya. Similar hurdles are experienced by a majority of small-scale farmers in the region.

“This is because many do not practise agriculture using an integrated approach,” he says.

Mr Kedar says that having high quality agricultural inputs or technologies — such as greenhouses — is not enough for farmers to excel in farming.

“These are just means for achieving the desired goal,” he says.

Part of the problem is that most Kenyan farmers do not have knowledge on good farming techniques and are incapable of implementing new technologies appropriately.

Again, the farmers do not have capital to start and sustain their agricultural enterprises, as well as markets for their products so as to generate sufficient income.

It was due to these hurdles that Amiran Kenya, where Kedar is the deputy managing director, started promoting an integrated approach to farming.

Amiran began selling low cost greenhouses to small-scale farmers in 2000. Before then, the technology was very expensive and was therefore a privilege for a few — mostly large-scale farmers in the horticultural flower industry.

Insufficient capital

“The idea was not to give farmers the greenhouses alone, as we already knew that this wouldn’t work,” he says.

“We also endeavour to connect farmers to outlets such as restaurants, green grocers and fresh juice companies that have a working relationship with us. But in instances where this is not possible, we offer guidance on possible markets for produce.”

For those farmers with insufficient capital, Kedar says that Amiran links them to financial institutions affiliated to it, which offer them friendly credit facilities.

Ndung'u is one of the beneficiaries. Now in his 30s, he ventured into agriculture in 2013 as a side business for generating additional income to adequately meet his needs.

As such, he says that the integrated farming approach — offered through the farmer's kit — has been extremely useful to him as he did not have a background in agriculture.

However, proper investment in modern irrigation techniques and greenhouses not only help farmers to cultivate more crops on their small parcels of land but also allows them to produce and earn an income all year round.

Jane's greenhouse tomato success story



From the look on her face we could tell with no doubt that Jane Wangechi a doctor by profession 27 years old life had turned around, when we went to pay her a visit in her office. This is one of the many successful comprehensive farming stories/interview purposely for people who are interested in greenhouse farming.

How did you come up with the idea of greenhouse farming?

Jane: I am a graduate from Nairobi university a doctor by profession, since childhood i loved farming, when we visited our grandparents i could go to their garden and started weeding. When i joined Nairobi university, i saved some money for keeping cows for milk at our family garden, though i never got the profits that i was expecting. In 2013 i did my own research about the much said greenhouse farming and decided to venture into green house farming.

Tell me the costs you incurred if you don't mind.

Jane: I spent about Ksh.600,000 i had in my savings to engage a professional to construct four greenhouses in our family farm all of them were 8m by 30m. One greenhouse was costing Ksh.150,000 which included everything from drip pipes, installations etc. but had to purchase the seeds and labor for planting.

Tell me about the big break

Jane: The returns were just amazing, i was just shocked. For the 4 greenhouses i harvested my first bunch of tomatoes within 78 days. I harvested a total of 9300 kgs and sold each kg at Ksh.108, that's translates on average 2325 kgs per greenhouse, In total Ksh.1,004,000. I thank God i was lucky there was no many pests to interfere with my tomatoes generally it was a good period for me. The reason why i attained this figure i think it's because there was insufficient tomatoes in the market.

How much do you make now considering the first months you made such huge margins

Jane. In good months i make Ksh.1.2M, but due to pests and maybe market saturation, prices fluctuate sometimes though not all the times i make an average of Ksh.950,000, and am not complaining.

After getting this break through what was your next move?

Jane: I had to quit my job to concentrate on my farming business. I love what i do.

How many employees do you have?

Jane: I Have 3 permanent employees that are involved in the day to day running of the farm and when the job increases i usually hire casuals.

Which type of tomatoes do you plant in your greenhouse.

Jane: I usually plant two types Anna F1 and Tylka F1

Greenhouse farmers usually combine different horticulture's in their greenhouses, do you also do that?

Jane: I have heard of those ideas am yet to try them, for now am satisfied in tomatoes farming.

Being barely 30 and having all this money what challenges do you face?

Jane: I have never been carried away by money, lets just say it depends with one principals, and this whats have made me overcome so many challenges.

Many people may think its because you had a large capital to start with that's why you have made it this far.

Jane: That's where they get it all wrong, its not about money its about passion, its about determination, its about making it happen and with all this, money will prevail itself in one way or another. One can start with one greenhouse and keep on growing, its not a must they start with four greenhouses.

With so much stock do you manage to dispose all of it? and whom do you sell it to

Jane: I have a network of customers from Nairobi, Mombasa and Nakuru who come to get the tomatoes from my greenhouse, retailers and my neighbors as well. Luckily i manage to sell all my tomatoes.

What advice can you offer to a farmer who is aspiring to be successful like you are in greenhouse farming?

Jane: First of all many people visit me and ask me for advises, to someone out there who want to make it in greenhouse farming i can tell them the same way i usually tell the others its about determination, it doesn't matter how much you have to start with, start small with one greenhouse and the rest will set itself in motion.

Young farmer (Ms Maryanne Wairimu – 23) makes a fortune selling seedlings



The difficulty of finding a job in Kenya has seen many young people pursue the opportunities in agribusiness rather than spend years looking for employment. One such person is Ms Maryanne Wairimu Kinuthia, 23. But unlike those who take up farming by chance, Ms Wairimu has always been interested in agriculture as it has been her family’s mainstay.

Business Beat found her tending to seedlings in a nursery bed in a greenhouse on her parents’ farm in Kiserian, Kajiado County. Like many successful entrepreneurs, she started her business to fill a gap she saw in the market. “After finishing my studies in 2012 and getting a diploma in technology and physics from the Technical University of Kenya, formerly the Kenya Polytechnic, I decided to get into farming seedlings instead of waiting a year to get a job. “I had come across farmers who were struggling to find specific fruit or vegetable seedlings, so I was confident I would have a market,” says Wairimu.

She started researching how to roll out her idea by utilising greenhouse technology, and armed with a capital of Sh.100,000 — from her savings and Sh.70,000 from her parents — she was ready to get started. Today, Wairimu is the proprietor of Gad-Eden Greenhouse Seedlings

and Nursery, a company that sells horticulture seedlings. In addition, she also harvests vegetables and fruits from her demonstration farms, which she sells to hotels and supermarkets.

DRIP IRRIGATION INSTALLATION

She owns two greenhouses, one measuring 5m by 10m and another 8m by 15m, where she propagates her seedlings, and uses a drip-irrigated field for practical demonstrations.

Wairimu also travels to clients' farms to install drip irrigation units.

“Due to my experience and training I got from Syngenta, I have become an expert in setting up drip irrigation, which I do free of charge.

However, I charge a Sh.3,000 consultation fee.” Her firm has five employees — her mother is the director in charge of day-to-day operations, she is the marketing manager, and there are two agronomists and a casual labourer. Wairimu's market has grown by leaps and she now exports seedlings across East Africa, and gets both small and large-scale orders.

“Initially, it was a struggle to get the business off the ground. But today, our turnover is good thanks to the growth in the number of customers. “People have learnt about Gad-Eden mostly through Facebook, our website where online bookings for seedlings are done and from referrals, including some from Syngenta.

I am earning a decent living from it,” says Wairimu. On average, she earns Sh.10,000 a week from the sale of seedlings, whose prices start at Sh.3.

She also holds trainings on her farm once a month, which she publicises through posts on Facebook and texts to the contacts she has in her visitors' book.

The trainings are conducted by Syngenta and other stakeholders in agribusiness. GROWING DEMAND And the demand for her services seems incessant. During the interview, she got several phone calls from clients asking about seedlings or wanting to have drip irrigation installations done.

Is it ever too much "I am happy doing what I do. Farming allows me to manage my time, plan ahead and I get to meet people who advise and encourage me."

However, Wairimu warns that starting and running a business like hers is not easy; it requires one to work hard, be available and establish a market for produce.

Wairimu started with a 5m by 10m greenhouse made with regular nylon paper, but she kitted it with a special kind of soil she got from an importer from Sweden and plant trays from local shops. "As a result, our seedlings are disease resistant, grow vigorously, have uniform maturity and a long shelf life."

To illustrate just how fulfilled she is with her business, Wairimu says she currently has no challenges. "For now, I have a ready market, so I have no stale stock. And even if I have seedlings that don't sell, I can still grow them into mature fruit and vegetables for sale," she says.

Her advice to young people looking for jobs "If you are interested in agribusiness and your parents have land at home, do something on the farm and it will earn you some cash as you wait for your dream job." She adds that since people need to eat every day, farmers are unlikely to lack customers.

Her plans for the future “In five years’ time, I see myself owning a large plot of land, about 10 acres, where I will expand my greenhouse and carry out intensive farming.”

Conclusion

Is greenhouse farming really profitable?

For instance a six by 12m plot can hold about 300 plants. One plant has a potential of up to 15 kg at first harvest, going up to 60 kg by the time it has completed its full cycle — recommended at one year.

The greenhouse will produce 10 tons of tomatoes per year. With a kilo of the product going at about Sh40, this adds up to Sh.400,000

The cost of setting up the greenhouse being Sh.150,000, you can see that it is a potentially profitable venture.

Finding funding has always been the most challenging part in any business. A lot of amazing ideas have been put on hold because of this major setback and everyone assumes that their business idea will never pick off from the ground due to lack of major funding behind them.

Let that not stop you. Am going to show you how to get easy capital to buy a greenhouse today. According to the Amiran Kenya Website The Youth Enterprise Development Fund (YEDF) and Amiran Kenya Ltd have partnered to support young farmers in acquiring a tailor made Amiran Farmers Kit (AFK) designed specifically for the AgriVijana Loan. The AgriVijana Loan was started to help young farmers in groups, to get involved in Agribusiness by purchasing the special AFK's each with 2 greenhouses and a large irrigated area.

The Farmer's Kit, contains 2 greenhouses, drip irrigation system for the greenhouses and 400m of open field, a water tank, plant support system, Gold Medal Seeds to be grown inside the greenhouses and in the open field, high quality fertilizers for one season, crop protection products for one season, a farmer's sprayer, nursery set, health and safety protective gear,

training, agro-support, and AFK insurance. The loan allocated by the YEDF to acquire an AgriVijana AFK is Kshs.358,344.

The group is expected to raise 10% of the loan amount. Repayment will start after a 4 month grace period, which is adjustable in the case that the crops planted by the group take longer to mature. The loan shall be repaid in three cycles totaling to 3 years.

Each cycle of 12 months shall be as follows; the first four months after installation of greenhouse shall be grace period, 5- 8 months is the high yielding season therefore, the group will pay Ksh.17,425 per month and 9-12 months is the lower yielding season in which the group will pay Ksh.10,000 per month during this period.

The security of the loan will be the financed equipment, assignment of sales and personal guarantees by group members. There are a number of qualifications for getting the loan most importantly that the group's composition must be 70% youth (18-35 years) with the leader being youth and must be registered in the constituency it's applying the loan from.

Other qualifications include access to land and water and knowledge or experience in agriculture. The groups must also show evidence of ability to raise the 10% of the investment outlay and be registered with the relevant government ministry. Groups with sponsors /guarantors will have an added advantage.

We have come to the end of this ebook. It is my hope that you have learnt a lot of things and this ebook has been beneficial to you.

I wish you success in your quest to become a profitable farmer.

Thanks for taking your time to read this guide. Am still writing more and more Agribusiness guides that will nourish you in your profitable farming endeavors. Always keep in touch with me on whatsapp **0714723004** to get more of my Agribusiness guides and Agribusiness advice.

Also whatsapp me and give me your feedback about this guide...

