IICA

Inter-American Institute for Cooperation on Agriculture

Climate Smart Agriculture System

Shadehouse Production Manual

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Shadehouse Production Manual

This publication is also available in electronic (PDF) format from the Institute's Web site: http://www.iica.int

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Printed: IIICA Print Shop

Climate smart agriculture systems: shadehouse production manual / Inter-American Institute for Cooperation on Agriculture. – Guyana : IICA, 2017.
44 p.; 21,6 cm X 28 cm.

ISBN: 978-92-9248-694-5

1. Climate change 2. Hydroponics 3. Greenhouses 4. Protected cultivation 5. Trickle irrigation 6. Innovation adoption I. IICA II. Title

AGRIS F01 DEWEY 631.583

Georgetown, Guyana
2017

Foreword

"A green economy is necessary to ensure the sustainable management of our natural resources."

President David Arthur Granger, Cooperative Republic of Guyana

The core of IICA's Medium-Term Plan (2014-2018) focuses on Agriculture: Opportunities for Development in the Americas. More specifically, Strategic objective 3 highlights the importance of improving agriculture's capacity to mitigate and adapt to climate change and make better use of natural resources. Through the financial support of the IICA Resilience and Inclusion Flagship Projects, the IICA Delegation in Guyana was able to work with selected communities to impart proven protected agricultural production systems and practices, increasing rural income and food security.

Over the years, hydroponics production has gained popularity with commercial scale-up operations, high schools, peri-urban settings and remote communities where fresh vegetables are for the most part non-existent. Practitioners of this production technique have been supported by our collaborative effort with the ministries of Agriculture and Education, Partners of the Americas and the FAO. Extensive work has been completed and results and best practices are being documented for dissemination to current and potential practitioners.

We are pleased to present this revised version of our Hydroponics Manual. It was prepared to serve as a guide to those who are interested in the technique, and to our users who are familiar with it. I also take this opportunity to thank the staff of the IICA Delegation in Guyana and the leaders and coordinators of the IICA Resilience and Inclusion Flagship Projects for their continued support.

Wilmot Garnett
IICA Representative in Guyana

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Background

Hydroponics is an ancient technique that dates back approximately 2600 yrs.

The first application of hydroponics in recorded history was the hanging gardens of Babylon that was built by **KING NEBUCHADNEZZAR.**

Egypt and China also practice hydroponics on Chinampas.

It was **Dr. W. F Gericke** in 1936 of the University of California who introduced the term Hydroponics from the Greek **hydro** (water) and **ponos** (work), meaning working with water. Dr. Gericke was the first person to carry out large-scale commercial experiments in which he grew tomatoes, lettuce and other vegetables.

Hydroponics was also used during World War II between 1939 and 1945 to provide vegetables for the troops (in arid soils and in Greenland).

NASA currently uses the hydroponics technique to provide food for space travelers.

Introduction

Crop production, which is vital to global food security, is being affected by climate change all over the world. However, the impact is being felt more severely in the more impoverished communities. It has been predicted that over the next decades, billions of people, especially those living in developing countries, will face shortages of water and food, as well as greater risks to health and life because of climate change. With fewer social, technological and financial resources for adapting to changing conditions, developing countries are the most vulnerable to the impacts of climate change (UNFCCC, 2007).

The IICA Delegation in Guyana has introduced a number of alternative methods that seek to improve the overall efficiency, resilience, adaptive capacity and mitigation potential of production systems throughout the regions. One such system to be noted is ***"Protected Agriculture"*** which is supported by efficient water harvesting and usage.

1. What is protected agriculture?

Protected agriculture may be defined as the modification of the natural environment to achieve maximum growth. This technology is now a method of choice due to uncontrolled environmental factors that have resulted in a decline in crop production, poor soil types, flooding and pest and diseases.

Advantages of protected agriculture

Protected agriculture offers many advantages:

- Large increase in yield, produce quality and revenue.
- High water productivity, saving significant amounts of water
- Significant reduction in pesticide use – lower production costs, healthier produce.
- Year-around production, allowing farmers to take advantage of market seasonality and higher prices.
- Increased control over crop nutrition
- Improved quality and consistency of crops

2. What is drip irrigation?

Drip irrigation is a form of irrigation that conserves water and fertilizer by allowing the water to drip slowly to the plant roots, either onto the soil surface or directly onto the root zone through a network of valves, pipes, tubing and emitters.

Advantages of drip irrigation

- Maximum use of available water.
- No water available to weeds.
- Maximum crop yield.
- High efficiency in the use of fertilizers.
- No soil erosion.
- Less loss of water through evaporation, as compared to surface irrigation.
- Less runoff, resulting in less pollution.

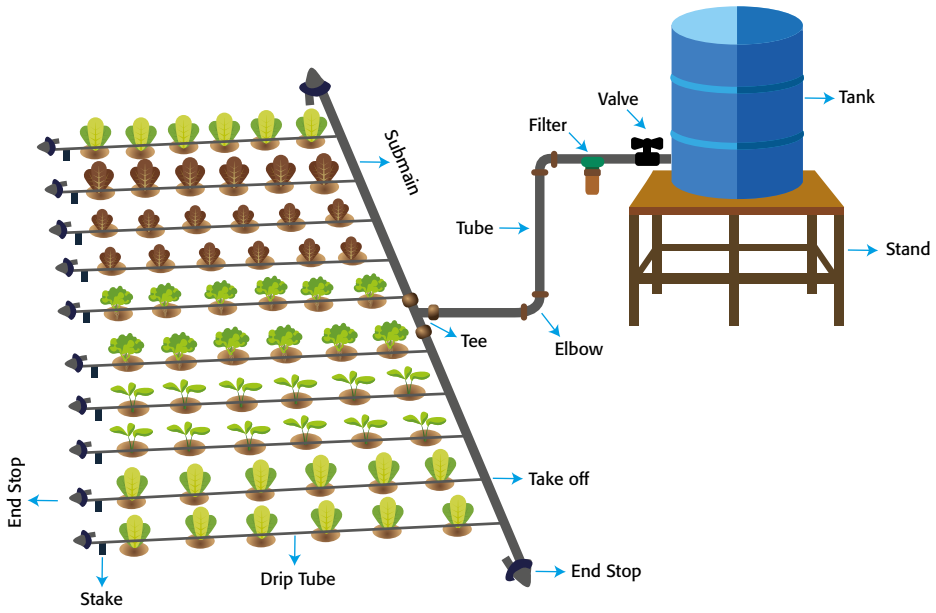


Illustration by Karla Cruz, IICA.

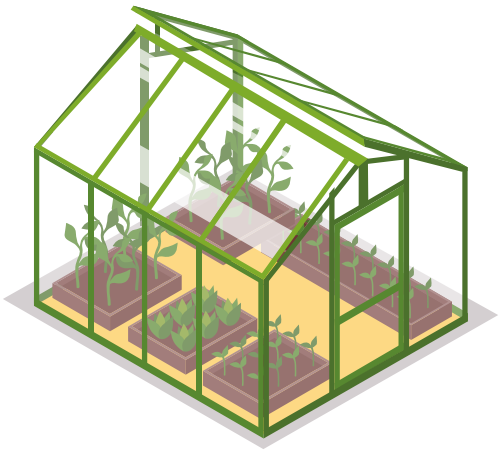
3. Types of protected agriculture structures

Various structures have been used in protected agriculture in an effort to control the natural environment and mitigate climate change. Following a massive flood that hit the coastlands in 2005 the technology was introduced using the two-roof, single-ridge structure that is commonly known as the police cap. Hydroponics was the preferred method of production applied under this system.

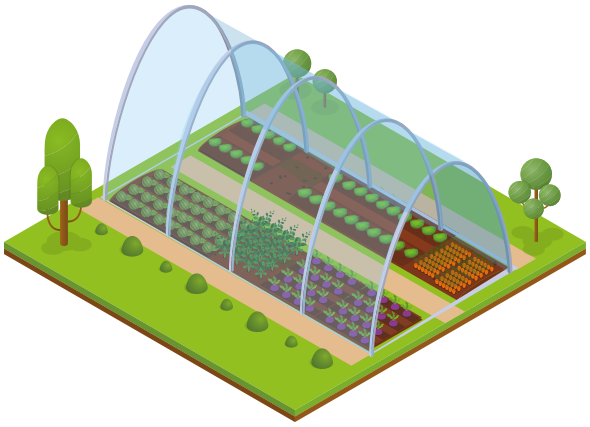
Some other types of Protected Agriculture structures include:

Low Tunnel Structure

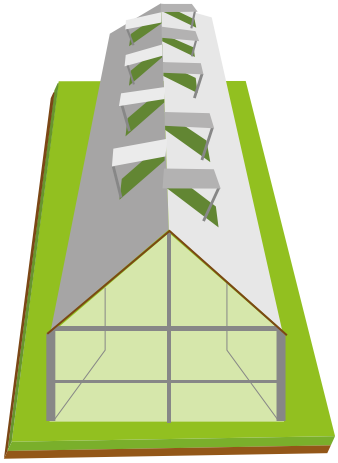
Two-Roof, Single-Ridge (Police Cap) structure



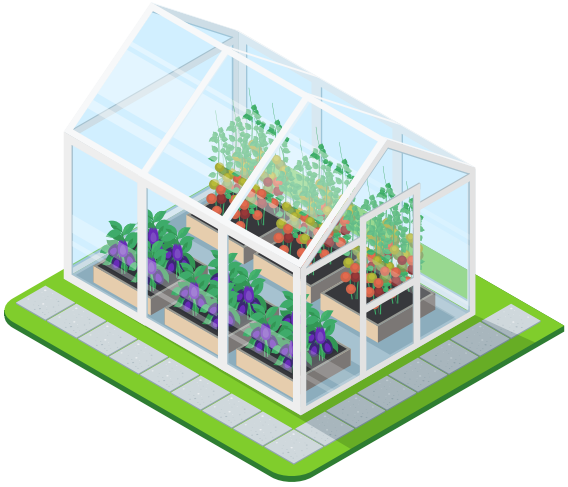
High Tunnel Structure



Double-Ridge Structure



Greenhouse structure which provides greater control of the environment



4. What is hydroponics?

Hydroponics is often defined as ***"the cultivation of plants in water."***

Hydroponics is however a technique for growing plants without using soil. Utilizing this technology, the roots absorb a balanced nutrient solution dissolved in water that meets all the plants developmental requirements.

Research has determined that many different aggregates or media can support plant growth, therefore, the definition of hydroponics has been broadened to: "the cultivation of plants without soil."

Advantages of hydroponics

As demonstrated by research activities, including field trials, hydroponics is a far more economical and profitable technique than traditional agricultural cultivation.

Some of the advantages noted:

1. The possibility of obtaining more products in less time than using traditional agriculture
2. The possibility of growing plants more densely
3. Possibility of growing the same plant species repeatedly because there is no soil depletion

4. Plants have a balanced supply of air, water and nutrients
5. More product/surface unit is obtained
6. Cleaner and fresher products can be reaped
7. Production can be timed more effectively to satisfy market demand
8. Healthier products can be produced
9. Products are more resistant to diseases
10. Natural or Biological control can be employed
11. Soil borne pests (fungi) and diseases can be eliminated
12. Troublesome weeds and volunteer seedlings which result in the need for herbicides use and increase labour cost, can also be eliminated
13. Reduction of health risks associated with pest management and soil care
14. Reduced turnaround time between planting as no soil preparation is required
15. Stable and significantly increased yields and shorter crop maturation cycle
16. Can be utilized by families with small or no yard space
17. When water is used as the substrate:
    a. no soil is needed
    b. the water stays in the system and can be reused - thus, lower water costs
    c. It is possible to control nutrition levels in their entirety - thus, lower nutrition costs
    d. No nutrition pollution is released into the environment because of the controlled system
18. Pests and diseases are easier to eliminate rid of because of container mobility

Disadvantages of hydroponics

1. Commercial scale requires technical knowledge as well as a good grasp of the principles.
2. On a commercial scale, the initial investment is relatively high.
3. Great care and attention to detail is required, particularly in the preparation of formulas and plant health control.
4. A constant supply of clean water is required.

5. Production system

Hydroponics can be classified as:

- Open system; or
- Closed system

Open system

In the open system of hydroponics, the nutrient solution is mixed and applied to the plant as required, instead of being re-cycled. Examples of some open systems are:

Growing beds

Columns made out of tubular plastics or vertical and horizontal PVC pipes

Individual containers e.g. pots, plastic sacks and old tires

Closed system:

In this system the nutrient solution is circulated continuously, providing the nutrients that the plant requires. Examples of closed systems include:

Floating roots

Nutrient Film Technique (NFT)

PVC or bamboo channels

Plastic or polystyrene pots set up in columns

6. Shadehouse Design

Figures 1 - 6 show various sketches related to the design and construction of an 18ft x 24ft shadehouse. A shadehouse could be of any size, but this 18ftx24ft size is considered to be the smallest commercial size.

The sketches are as follows:

Figure 1: Floor Plan
Figure 2: Floor & Planting Trays Layout
Figure 3: Front Elevation
Figure 4: Section A-A (Showing Side Elevation of Roof – Policeman Cap Design)
Figure 5: Roof Framing Plan
Figure 6: Door Elevation and Section

Figure 1: floor plan

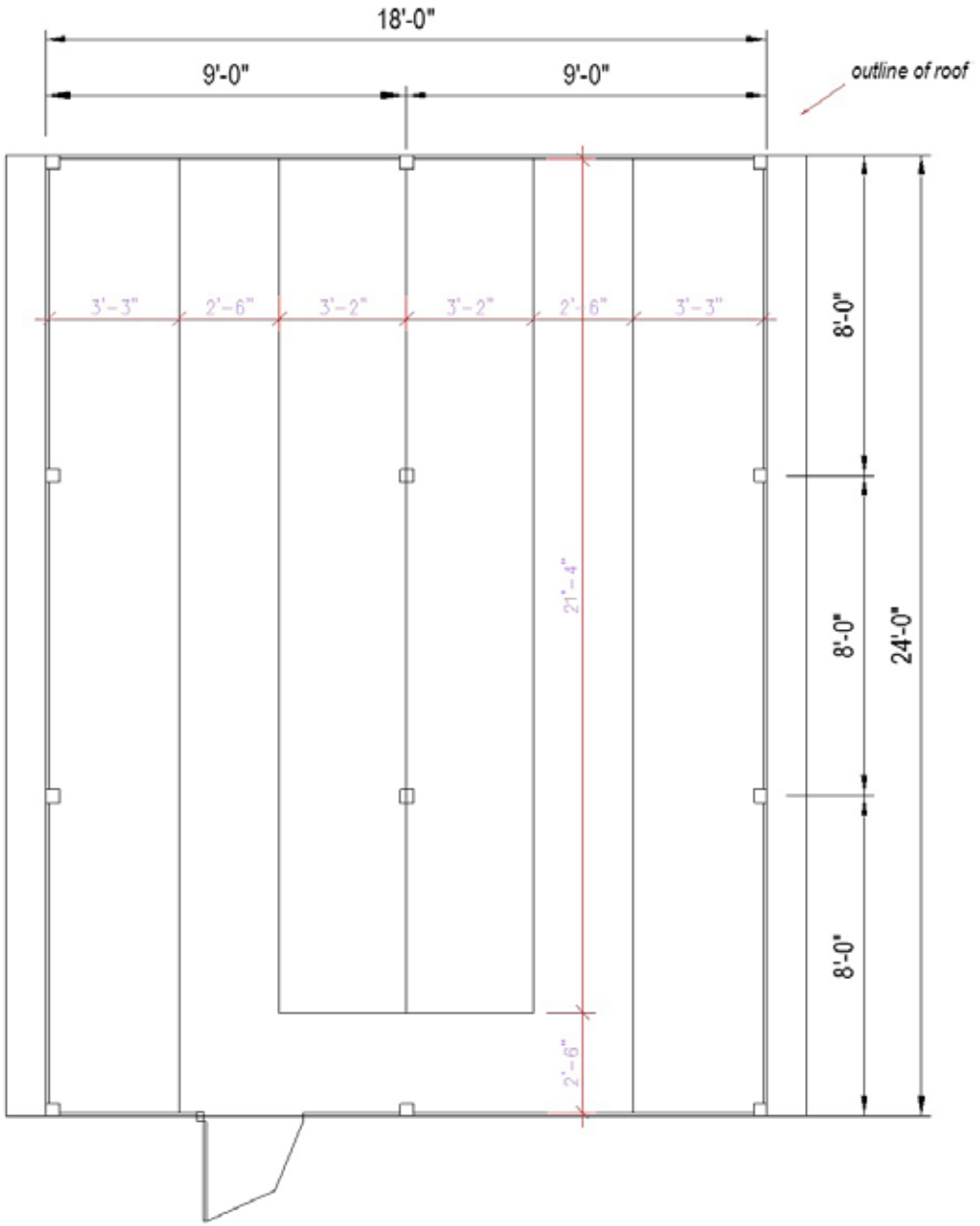
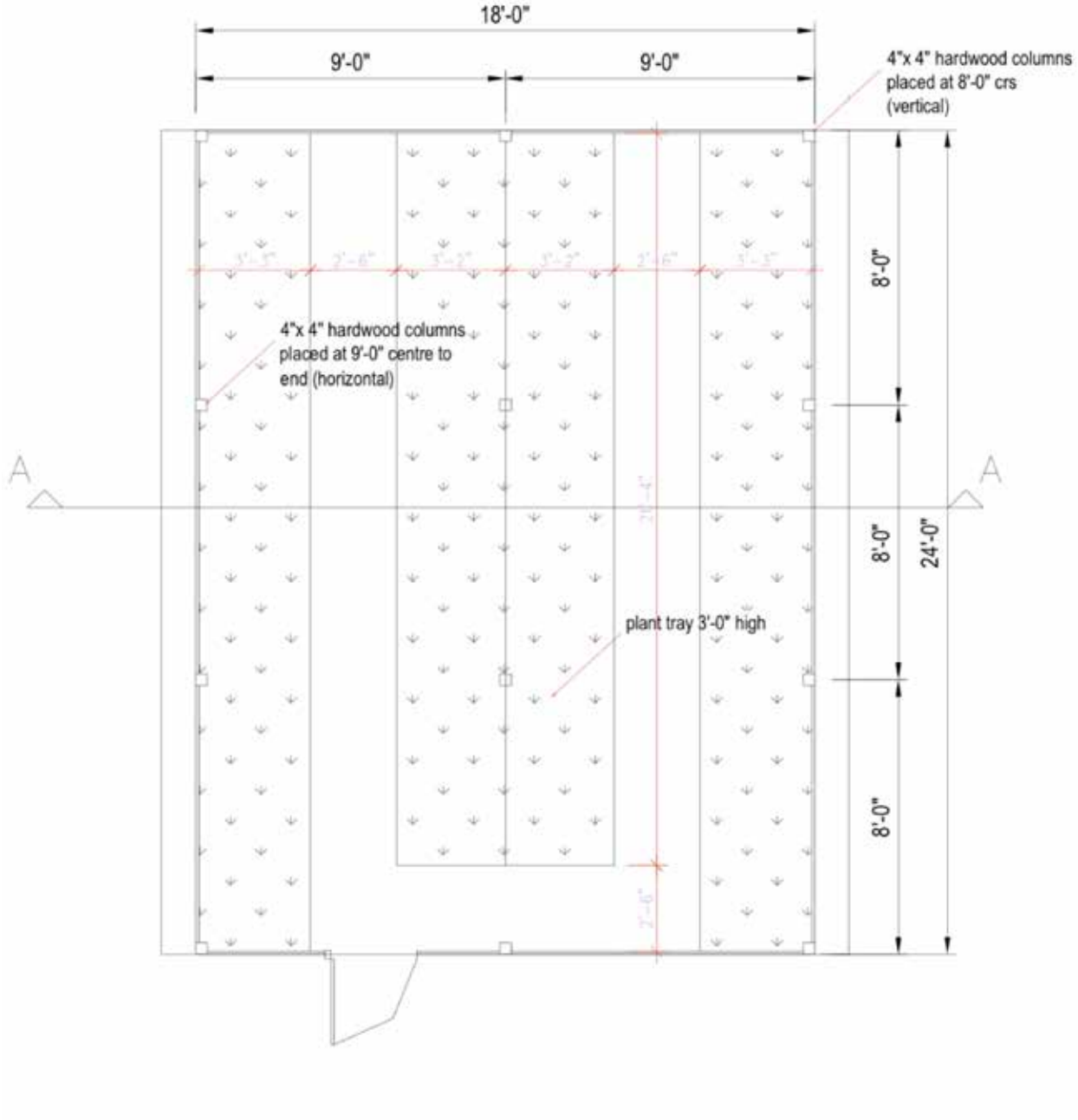


Figure 2: layout of floor & planting trays



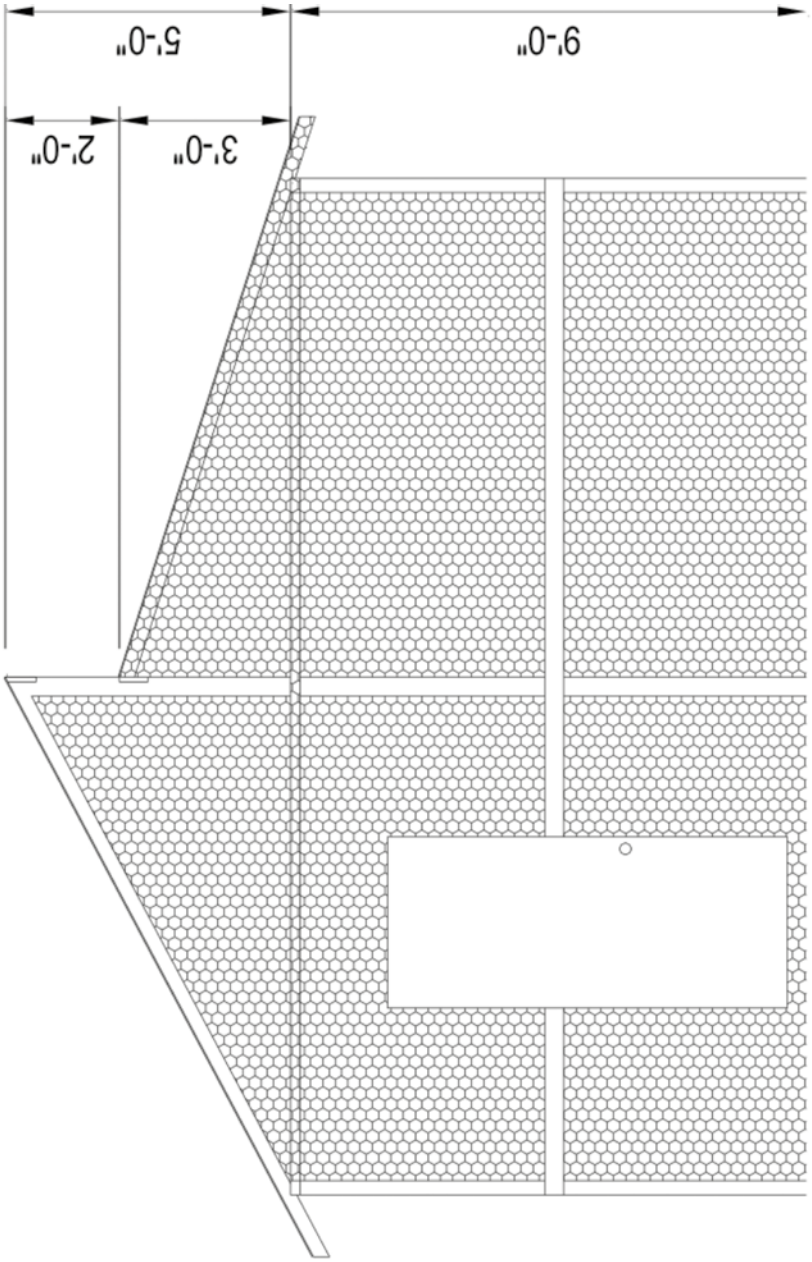


Figure 3: front elevation

Figure 4: section a-a (showing side elevation of roof – policeman cap design)

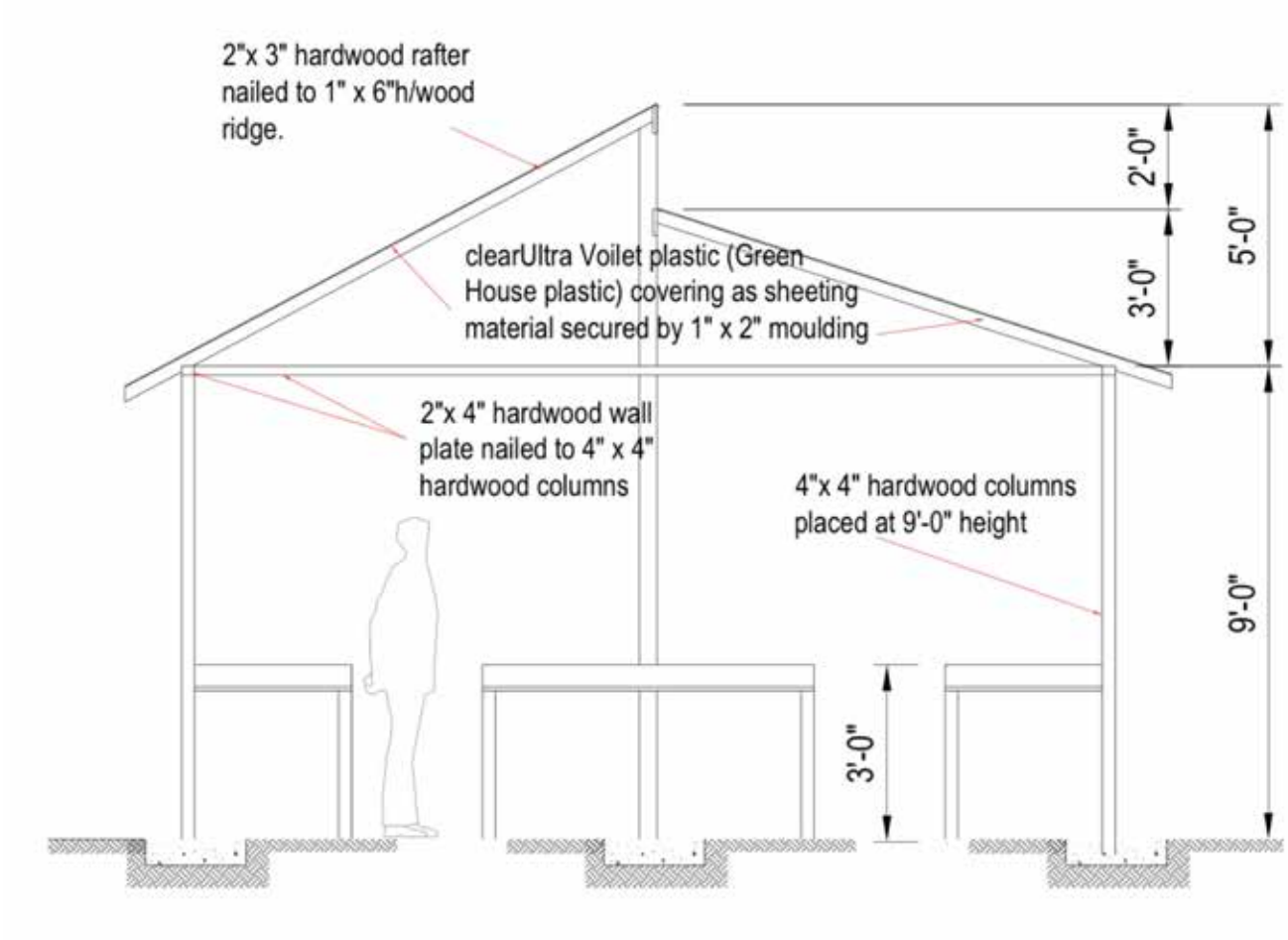


Figure 5: roof framing plan

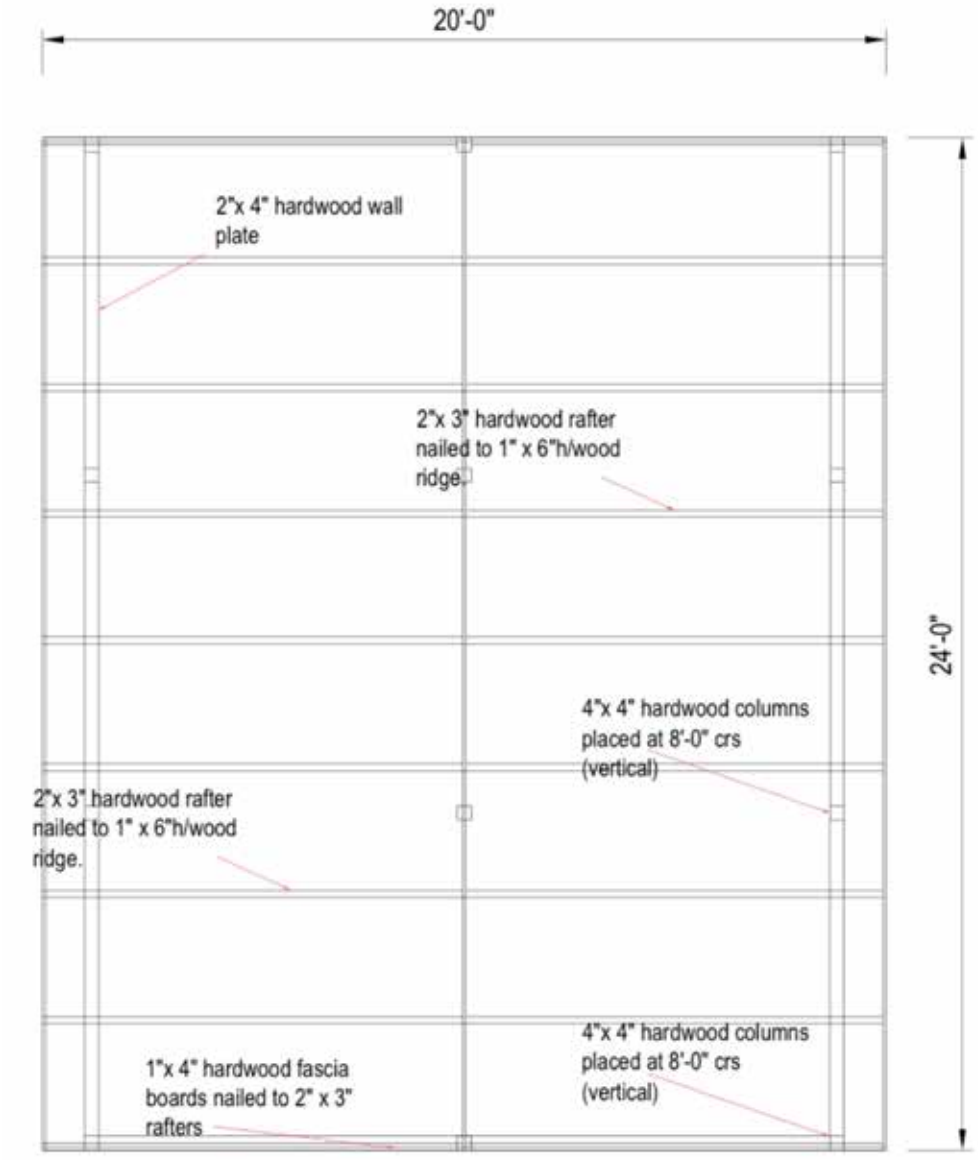
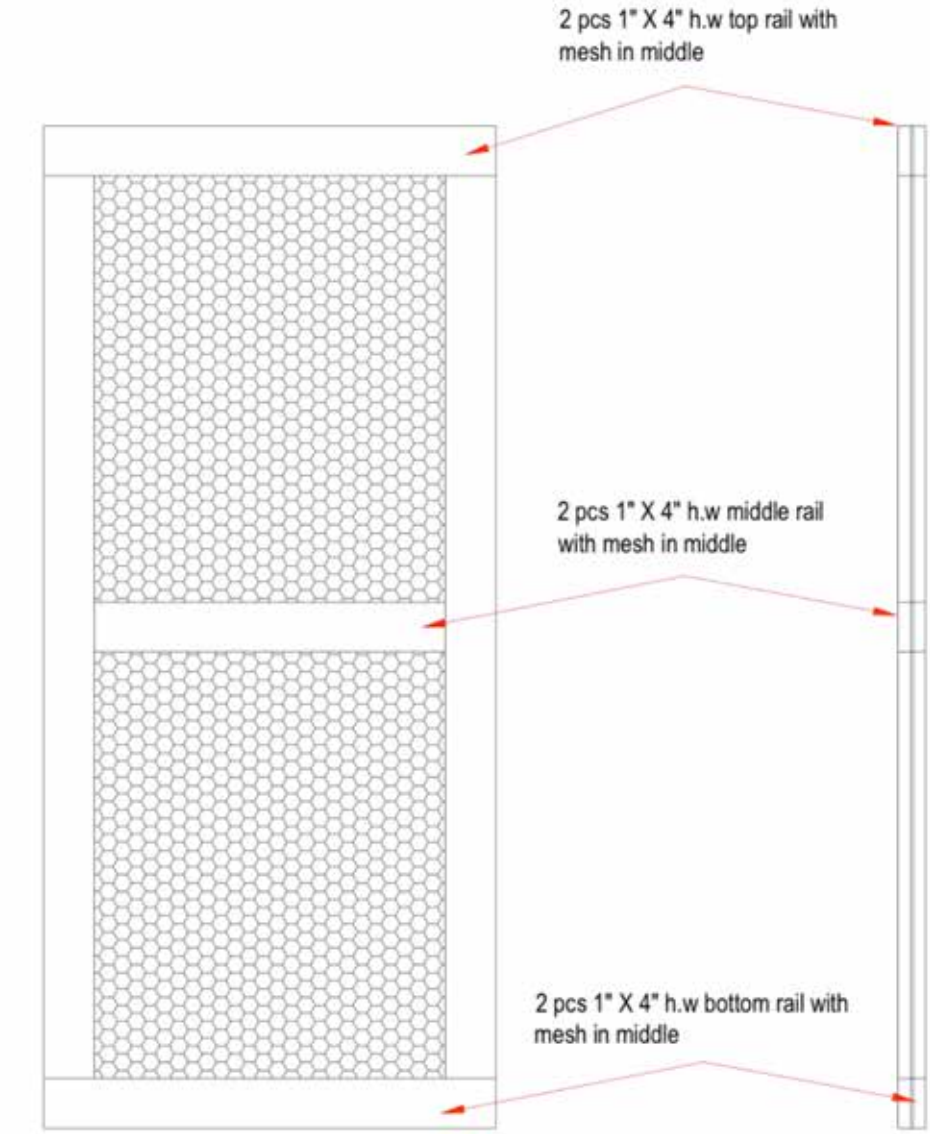


Figure 6: door elevation & section



7. Estimate for construction and operation of low cost/tech 18ftx24ft shadehouse

Item	Description		Qty	Unit Cost $	Total Cost $
Hardwood	4 * 4 main post (8 ft)	85 BM	8 pc	225	19,200
Hardwood	4 * 4 main post (13 ft)	69 BM	4 pc	225	15,600
Hardwood	*Plate*				
Hardwood	2 * 4 (24 ft)	32 BM	2 pc	225	7,200
Hardwood	2 * 4 (18 ft)	24 BM	2 pc	225	5,400
Hardwood	*Rafters*				
Hardwood	2 * 3 (11 ft)	44 BM	8 pc	225	9,900
Hardwood	2 * 3 (13 ft)	52 BM	8 pc	225	11,700
Hardwood	*Facing*				
Hardwood	1 * 4 (24 ft)	64 BM	8 pc	225	14,400
Hardwood	1 * 4 (18 ft)	48 BM	8 pc	225	10,800
Hardwood	*Boxes*				
Hardwood	1 * 10 (12 ft)	23 BM	2 pc	225	5,250
Hardwood	1 * 10 (24 ft)	80 BM	4 pc	225	18,000
Hardwood	1 * 10 (22 ft)	55 BM	3 pc	225	12,375
Hard wood	1 * 12 (24 ft)	144 BM	6 pc	225	32,400
Hard wood	1 * 12 (22 ft)	132 BM	6 pc	225	29,700
Hardwood	2 * 4 (54 ft)	36 BM	1 pc	225	8,100
Hardwood	2 * 4 (48 ft)	32 BM	1 pc	225	7,200
	450 Gal water tank		1	28,000	28,000

Item	Description	Qty	Unit Cost $	Total Cost $
Nails	2 ½ "	10 lbs	360	3,600
Bolts & Nuts	6 "	16	200	3,200
	Construction plastic			
	UV plastic	50 ft	1000	50,000
	Shade net	1 roll	32,000	32,000
	Insect mesh	86 ft	450	38,700
	Plants	621	12	7,452
	Labour			150,000
	Hydroponics Solution			
Solution	A	12	1,500	18,000
Solution	B	6	1,500	9,000
Solution	C	12	1,500	18,000
	Organic pesticide	250 ml	7,000	7,000
	Paddy shell	40 bags	100	4,000
	Sand	20 bags	500	10,000
Grand Total				**586,177**

	Estimated Qty per Crop Cycle					Est. Unit Cost	Total Cost/Crop/cycle				
Operating Cost	Celery	Lettuce	Pak-choi	Hot Peppers	Tomatoes		Celery	Lettuce	Pak-choi	Hot Peppers	Tomatoes
Number of Plants	621	621	621	123	123	12	7,452	7,452	7,452	1,476	1,476
Hydroponics solution								0	0	0	0
A	12	12	12	3	4	1,500	18,000	18,000	18,000	4,500	6,000
B	6	6	6	1.5	2	1,500	9,000	9,000	9,000	2,250	3,000
C	12	12	12	3	4	1,500	18,000	18,000	18,000	4,500	6,000
Organic pesticide (250 ml)	1	1	1	1	1	7,000	7,000	7,000	7,000	7,000	7,000
Paddy shell	40	40	40	40	40	100	4,000	4,000	4,000	4,000	4,000
Sand	20	20	20	20	20	500	10,000	10,000	10,000	10,000	10,000
Total Operating Cost							**73,452**	**73,452**	**73,452**	**33,726**	**37,476**

Revenue Calculations Per Annum

Crop	Yield	Output-loss	Market volume	Price/unit (g$)	Revenue (g$)
Celery (8)	1,242 lbs	87 lbs	1,155 lbs	1,500/lb	1,732,500
Lettuce (8)	1,300 lbs	91 lbs	1,209 lbs	100/root	496,800
Pak-choi (8)	2,484 lbs	174 lbs	2,310 lbs	100/root	496,800
Hot Peppers (7)	21,525 lbs	1507 lbs	20,018 lbs	300/lb	6,005,400
Tomatoes (5)	15,375 lbs	1076 lbs	14,299 lbs	300/lb	4,289,700

8. Building and positioning the planting trays

Planting trays or grow boxes are a fundamental part of the structure. They can be built about 3ft above the ground based on builder convenience and purpose. (e.g. above the height of all normal flood prone areas along the coast). The elderly and physically challenged individuals can utilize these elevated grow boxes with much comfort and at their own convenience. In the case of individual trays, it is recommended they be constructed 1-meter-wide to allow for easy access to all sides. Note that the walkways are recommended to be about 2 feet 6 inches wide to allow for ease of access around the side trays.

Characteristics of a good substrate:

- It must be made of particles no larger than 7mm and no smaller than 2mm
- It must be capable of maintaining moisture and draining excess liquid
- It must not degrade or decompose easily
- It must not hold microorganisms that are hazardous to human or plant health
- It must not be contaminated with industrial residual waste
- It must be readily available
- It must be potable

Recommended Substrate Mixtures

Some recommended substrate mixtures are:

- 50% rice hull : 50% ground volcanic stones
- 60% rice hull : 40% sand
- 60% rice hull : 40% ground clay bricks

Another substrate which could be used is:
- Clean rain water

Rice hulls

These must be washed and kept very moist for ten (10) days in order that all seeds in the rice hulls will germinate. The germinated seedlings must be removed.

All containers to be used for substrate planting must have a drain through which excess water or nutrients are discarded. If the container is to be used for floating roots or Nutrient Film Technique (NFT), it will not require drainage.

9. Sowing methods

Direct sowing

Not all species need to be planted in a seed box or in seed trays. Some plants may be sown directly in the growing medium, either because they will not resist being transplanted, or because they grow enough and do not need special care during the first week.

Plants which can be sown directly:

- Garlic bulbs
- Carrot
- Beans
- Watermelon
- Coriander
- Pumpkin
- Cucumber
- Cantaloupe
- Radish
- Eschallot
- Ochro

Plants that are reproduced using a part of the original plant (vegetative production) are also planted directly.

Indirect sowing

Seed beds, seed trays and transplanting:

Very small seeds that are fragile and need special care are grown either in seed boxes or in seed trays, which will guarantee stronger development. Most hydroponics systems utilize seedlings that were grown in a seed box or tray.

Plants which require seed boxes or trays;

- Onions
- Mustard
- Tomato
- Cabbage
- Pepper
- Cauliflower
- Lettuce
- Celery
- Parsley

The time from germination to transplanting depends on the vegetable specie, as shown in the table below:

Crop	Days To Germinatioin	Days To Transplant	Days To Harvesting
Hot pepper	8	18	50
Sweet pepper	12	15	80
Tomato	7	15	70
Lettuce	4	18	40
Parsley	12	18	55
Celery	12	18	40

Nutrients and fertilizers

The hydroponic solution contains a balanced amount of nutrients to produce healthy and productive plants. In addition to the elements (carbon, hydrogen, oxygen) that vegetables extract from the air and water, plants need some elements that may be classified by quantities and need.

Large	Intermediate	Small
Nitrogen	Sulphur	Iron
Phosphorus	Calcium	Manganese
Potassium	Magnesium	Zinc
		Boron
		Molybdenum

Ecag hydroponic fertilizer solution	
For four (4) liters of water:	
A. CONCENTRATED SOLUTION OF MAJOR NUTRIENTS	
	GRAMS
Mono-potassic Phosphate	190.0
Magnesium Sulfate	400.0
Potassium Nitrate	440.0
B. CONCENTRATED SOLUTION OF MINOR NUTRIENTS	
	GRAMS
Trace Elements	20.0
Boric acid	4.6
C. CONCENTRATED SOLUTION OF N C	
	GRAMS
Calcium Nitrate	590
DOSAGE	
Solution	cc. per 1 liter of water
A	5.0
B	2.5
C	5.0

When to apply plant food:

Plant food solution should be applied six days per week, from 7 am to 9 am, and on the 7th day, apply only water. The water on the 7th day aids to flush out excess salts/nitrates in the substrate.

Solution B

This solution can be applied to plants that were transplanted, and seedlings after sprouting from day 0 until day 7.

10. Pest control

For the control of pests, we may use natural products such as pepper, garlic and tomato. These have the following advantages:

- ✓ They are non-pollutant
- ✓ Pests do not develop a resistance to them
- ✓ No special equipment is necessary for fumigation
- ✓ They are easily made
- ✓ They are economical

Pepper solution

- Grind 3 ounces of pepper and add water
- Let stand overnight, strain and mix with 5L of soapy water
- Apply daily
- Controls: ants, worms, fleas, flies, chewers

Garlic solution

- Mix 3 ounces garlic with oil and let stand for 24 hrs
- Dissolve 10g of soap in 1L of water. Mix and strain and add 20L of water
- It may be used as repellant, pesticide, bactericide, fungicide and nematicide.

Tomato leaf solution

- Grind leaves and stems
- Boil in 4 bottles of water for 10 min.
- Let cool and apply
- Controls: Fleas, lice and hairy worms
- Do not apply on plants of the same family, such as pepper and eggplant

The cocktail of the above mixture can be used primarily as a repellant for a number of common insect pests. However, the cocktail can also control some fungal and bacterial diseases. It must be noted that basic crop husbandry practices of good sanitation are necessary. Some common pests and diseases that can be controlled:

- Caterpillars
- Aphids
- Leafhoppers
- White fly
- Scaled insects
- Army worm
- Bacterial blight and brown spots

11. Crop records

Date	Activity	Observation	Remarks

12. Fertilizer usage

Date	Type	Dosage/rate	Reasons	Remarks

13. Identification of diseases/insects

Date observed	Plant part affected	Symptom	Diagnosis	Date treated	Treatment	Remarks

14. Harvesting record

Date	By what means: hand pick; mechanical, etc.	Quantity (lbs/kgs) harvested
1st harvest		
2nd harvest		
3rd harvest		
4th harv est		
5th harvest		
6th harvest		
7th harvest		
8th harvest		
9th harvest		
10th harvest		
11th harvest		

Conclusion

Today, hydroponics is an established branch of agronomy.

Progress has been rapid and results obtained in various countries have proved that this technology is thoroughly practical and has very definite advantages over conventional methods of crop production.

The two main advantages of the virtually soil-less cultivation of plants are, the higher crop yields and hydroponics can be used in places where in-ground agriculture or gardening is not possible.

Thus not only is it a profitable undertaking, but one which has proved of great benefit to humanity. People living in crowded city streets, without gardens, can grow fresh vegetables and fruits in window-boxes or in small discarded containers. By means of hydroponics, a regular and abundant supply of fresh greens can be produced and barren and sterile areas can be made productive at relatively low cost.

References

MUNÕZ, Héctor. 2005. *Hydroponics Home-based Vegetable Production System Manual*. IICA, Georgetown, Guyana

ECHEVERRIA, Laura Perez. 2008. *Hydroponics for the Home*. IICA, San Jose, Costa Rica

ROBERTO, Keith. Fourth edition. *How-To-Hydroponics*.

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Our Commitment: Results

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