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FACT SHEET
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Urban Agriculture: Vertical Organic Farming

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Urban Agriculture: *The U.S. Census Bureau defines an urbanized area wherever it finds an urban nucleus of 50,000 or more people. Therefore, Urban Agriculture can be defined as agriculture activities that occur in a population density of 50,000 or more, where the density refers to 1,000 persons per square mile.*

1. INTRODUCTION

As the world population increases from the current population of ~7 billion to an estimated 9 billion[1], agriculture outputs must also increase to adequately feed this increased population. One of the challenges that agriculture faces is the need for space to increase production and subsequently feed a larger population. However, the additional population growth is expected to increase urban land use and continue the trend of decreasing farm acreage. Therefore, the question of how to feed the population while conserving land, water, and energy arises. Urban farming is expected to provide a sustainable solution for future generations.

The term vertical farming was first introduced in 1915 by Gilbert E. Bailey, Professor of Geology at University of Southern California[2]. In his book of the same name, he discusses the many considerations of soil and roots for farming. Modern vertical farming or vertical agriculture refers to a new paradigm altogether, that replaces soil with alternative media and provides the nutrients previously supplied by the soil environment with water soluble nutrients in a hydration system. This is referred to as drip irrigation, fertigation, hydroponics, or perhaps other names. The system provides the farmer with a three dimensional (3D) garden of plants allowing for 1 acre that previously grew crops in a 2D area to provide repeated sowing of seed in 3D (figure 1). In other words, one acre that once grew for example, 5,445 strawberry plants/acre (4' rows with 2' spacing of plants[3]) can support 27,225 plants/acre[4] in the vertical design.

Figure 1a: Indoor demonstration

Figure 1b: Outdoor demonstration (USVI)

Facts Included

As a point of interest, not all vertical gardens eliminate soil. One example is high-rise buildings landscaped vertically for air quality. This fact sheet focuses on the potential of drip organics or Organic Vertical Gardens.

2. Overview

Vertical gardening, as discussed herein, is a geometric method of scaling up production, which decreases area requirements. Traditional farming uses the ***area*** of an acre to grow crops, whereas vertical gardens use a ***volume*** of the acre, rising perpendicular to the area, providing additional growth opportunity in 3D space. Furthermore, hydroponic or drip irrigation practices replace soil with a simple growing media, which solves many soil-born issues.

Better land management is necessary to address the shrinking availability of land due to the continual spread in urban population. Vertical gardens can be simple, as in one stack on a patio or in a back yard, to complex systems populating several acres (figure 2)[3]. These systems work well indoors and outdoors. The financial commitment can be small or large depending on the needs of the individual or farm.

Vertical farming is sustainable. The structures are reusable, the media* is reusable and also compostable. Alternative forms of energy can supply the necessary energy to the pump(s) and the nutrient bath can be developed using organic ingredients.

As pressures rise to grow more food with less land, organic-drip, vertical gardens offer solutions. In addition to crop production for food, drip organics can be utilized on rooftops and interiors of skyscrapers for horticulture crops. In fact, urban green-space architects are advancing this technology with automatic system controls to minimize labor costs[5]. Urban farmers have untold opportunities to design crop production for the 21st century.

** Assumes coconut fiber media*

Fig. 2: Top: Acreage; Bottom: Hoop houses (courtesy: *Vertigro*)

3. Advantages

- Local food security
- Eliminates soil maintenance for nutrients
- Insulated media stabilizes media temperatures
- Weeding is minimal or non-existent
- Decreases insects/pests and diseases
- Uses less water (>80%[6])
- Less fertilizer, and less pesticides
- Organic, Sustainable
- Maximizes space
- Per plant cost is less
- Consistent nutrient availability to roots
- Ease of planting and harvesting
- Decreases space

4. Crop Options

Many options are available for use in a vertical design. The top pots in this design should not be root intensive claiming the majority of nutrients and depriving the lower pots of their fair share. Heavier fruits should be in the ground pot. Even horticulture crops will grow in this system. Consequently, there are many crop options.

Here are a few ideas. The organic farm at Tennessee State University is growing herbs and leafy greens in the current demonstration project. There are four varieties of coriander and two varieties of basil, along with a variety of greens (Table 1). However, many possibilities exist, such as sweet onions, garlic, peppers, cucumbers, other herbs, and horticultural crops (pansies, violas, etc.). In the ground pot, it is even possible to grow watermelon, cantaloupe, squash, eggplant and many more. Vertical gardening or farming deserves a place in 21st century farming techniques and practices.

Table 1: Vegetables, herbs, and leafy green varieties grown successfully in organic vertical garden as of October, 2015

Red Salad Lettuce	Verdi Spinach
Romaine Lettuce	Winter Giant Spinach
Rainbow Chard	Parris Island Lettuce
Greenwave Mustard	Ruby Red Swiss Chard
Giant Red Mustard	Sorrel
Tendergreen Mustard	Hybrid Tomato
Red Russian Kale	Bing Cherry Tomato
White Russian Kale	Rainbow Cherry Tomato
Cilantro	Basil

5. Design

This vertical design can be used in multiple environments. At Tennessee State University (TSU) Organic Agriculture Research Farm in Nashville, TN ten stacks with 4 planters each are set up in a hoop house (figure 1a, 4-9). Supplies were purchased as a kit from Verti-Gro, Inc[6]. These can be ordered in single stacks or for large farming operations. Do-it-yourself (DIY) folks can utilize common items found in hardware and home improvement stores.

Choosing a design begins with choosing the type of media, type of nutrient application, ease of harvest, as well as particular pests (Table 2) and disease options. Supplies should be food-grade, especially any plastics, such as PVC. Of course, initial investment and long-term use must be considered. Here is a *short* list of designs.

- DIY PVC assemblies or barrel assemblies (search out more information on the web)
- Hydroponic kits[6,7] (figure 4)
- Aeroponic Tower Garden kits[8] (figure 3a)
- Roof top and Wall Gardens[9,10] (figure 3b)

Figure 3, L to R: Aeroponic Towers; Roof top at Rodale

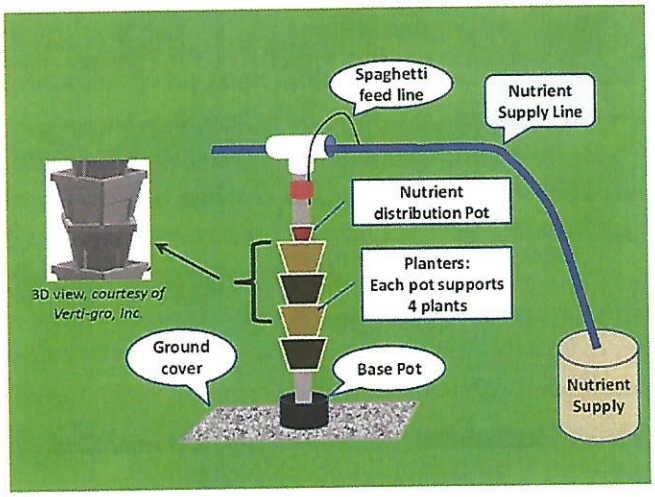

Figure 4: Vertical Stack Design Basics in organic drip system aka/hydroponic system .

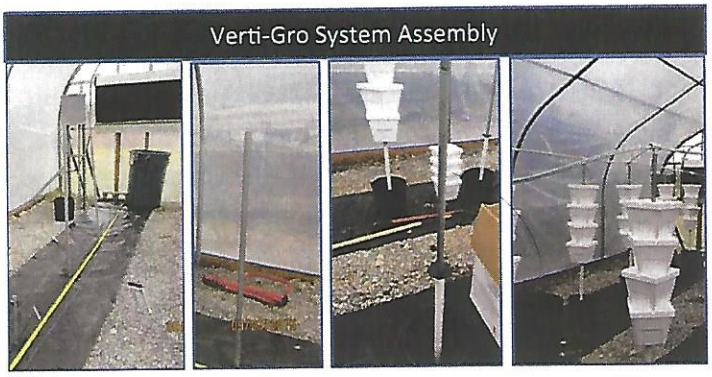

Figure 5, L to R: Ground cover, support installation, spacers, final assembly.

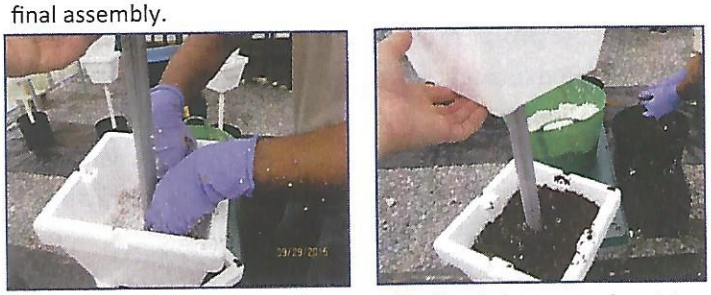

Figure 6, L to R: Addition of wet perlite for drainage, **and** moist coconut fiber for root support.

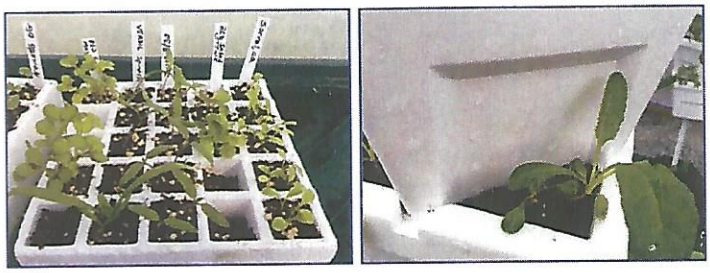

Figure 7, L to R: Floating seedlings; 1 of 4 transplanted seedlings/pot. Each corner has a transplanted seedling.

Figure 8: Compacted organic coconut fiber. Add water to expand to 16-18 gallons of loose fiber; and Perlite is a dusty volcanic rock, naturally mined. Wet before using.

Fig 9: 30 day growth

Table 2: Organic Pest Control	
DiPel	Neem Oil
M pede	PyGanic
Monterey BT	Safer-Insect-Killing-Soap
Mycotrol O	Suffoil X

6. Maintenance

Replacing the soil system when growing crops requires that all nutrients must be supplied for the plant. Nitrogen, phosphorous, and potassium, are the macronutrients plants depend on. These are the main nutrients farmers must maintain in the soil. However, plants also use other nutrients, micronutrients, in small or trace amounts. All of the plants' nutrient needs must be supplied in water soluble media and in appropriate ratios for the plant to thrive. Verti-Gro currently supplies these products (figure 10). The current system is using approximately 80 gallons of nutrient mix/week in a 44-gallon-capacity tank (Brute trash can), which means mixing nutrients twice a week. The concentration is 0.6 L of fermented molasses/151.4 L of water and the same for the 5-0-15 food, which is about 0.4% v/v for each. In addition, alternate bi-weekly applications of Fish Emulsion and Seaweed are applied to each stack of plants. These products release nutrients relatively fast, < 2 weeks.

Tomato plants require pollination. This means a gentle breeze must shake the plants or labor must be spent on this task. In the hoop house, the plants are situated in front of overhead fans that create air currents. The efficacy of this plan remains to be evaluated at this time.

The Verti-Gro system allows for easy plant rotation to insure maximum light, as some plants will be shaded by the pots or other plants. This can be overcome by rotating the entire stack of pots with an easy movement of the hand, due to a mounted, free-moving plastic disc beneath each stack of pots (figure 5).

Since these plants are in a hoop house environment, using coconut fiber (coir) in lieu of soil, weeds are practically non-existent. Therefore, no labor is involved in weeding.

This leaves the question of pests. Pests do find their way into the hoop house and the plants are periodically sprayed. For example, as the temperature decreased, spiders found the warm hoop house attractive. A few organic options to discourage pests are listed in Table 2 on page 3. Spray as needed.

Figure 10: Proprietary formulas from Verti-Gro, Inc. include Fermented Molasses, Seaweed, and 5-0-15 organic plant food.

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7. Additional Resources

- http://www.epa.gov/swerosps/bf/urbanag/pdf/bf_urban_ag.pdf
- http://www.newsworks.org/index.php/blogs/onward/item/54425
- http://afsic.nal.usda.gov/farms-and-community/urban-agriculture
- http://afsic.nal.usda.gov/farms-and-community/urban-agriculture
- http://www.ams.usda.gov/about-ams/programs-offices/national-organic-program

8. References

1 US Census Bureau, www.census.gov/popclock
2 https://archive.org/details/ Cu31924000349328
3 http://www.vertigro.com
4 http://strawberryplants.org/2010/10/strawberry-plants - per-acre/
5 Proc. IS on Soilless Culture and Hydroponics, Eds.: A. Rodriguez-Delfin, P.F. Martinez, Acta Hort. 843, ISHS 2009
6 http://vertigro.com/
7 www.tomorrowsgarden.net/
8 http://www.futuregrowing.com/info.html
9 http://www.rainharvest.com/

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