Sustainable Irrigation System for Rural Farming Operations

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Abstract

A solar-powered irrigation system was designed and implemented at the Bioenergy and Sustainable Technology Laboratory community gardens. The irrigation system was designed to harvest rainwater that would be dispersed through overhead sprinkler heads certified by Energy Star to promote water conservation. The irrigation schedule was set for the evening hours to minimize evaporative losses at a rate of 200 gallons/day unless daily rainfall was sufficient. The community gardens consisted of 1,800 square feet of seasonal vegetables planted in rows spaced 36 inches apart. The inter-row spacing varied from one to two feet, depending on the crop. The seasonal vegetables included potatoes, kale, squash, cucumbers, okra, peppers and eggplant. Transplants were planted from February 15th through March 15th and the harvest schedule extended from April 19th through September 4th. The crops were fertilized at a rate of 3 lbs N/1000 ft^2, based on recommendations following soil fertility analyses. The objective of the project was to develop a sustainable model for maximizing agronomic productivity for a diverse selection of nutritional vegetables with minimal water and power inputs, specifically for rural and/or low socio-economic communities. The agronomic harvest productivities for each crop were measured by pound of vegetable produced per plant and per acre. Agronomic productivities (lbs/plant) were highest for cucumbers (18), eggplant (10), and squash (5) and were lower for kale (1.8), okra (1.5), potatoes (1.0) and peppers (0.8). When expressed as lbs/acre, the crops descended in the same order and ranged from 260,839 lbs/acre for cucumbers to 12,232 lbs/acre for peppers.

Introduction

Sustainable Irrigation for Rural Community Gardens

Community gardens are evolving into a trendy environment for growing local food with multi-generational involvement. Public lands are often available to promote locally grown vegetables, community engagement, and productive land use. However, irrigation supply systems are not always available on public lands since there is no individual ownership and the cost for well installation and traditional pumping methods can be excessive. A sustainable approach to water resource management is to use rainwater harvesting and solar pumping technologies. This removes the costly burden of monthly water bills and, if designed appropriately, can provide a consistent water supply system for community gardens in rural areas where infrastructure is limited. Different types of structures can be equipped for rainwater harvesting including both stand-alone and roof-top models as shown below.

Stand-alone rainwater harvester at UF Bioenergy and Sustainable Technology Lab

Roof-top rainwater harvester at Gainesville Sweetwater Wetland Park

Objective

To design a solar irrigation system and rainwater collection system that will sufficiently irrigate an 1,800-square foot vegetable garden in Gainesville

Methods

Calculate Supplemental Irrigation Requirements based on Rainfall:

- Gather monthly precipitation averages reported by the National Weather Service for the Gainesville Regional Airport Station and compare with actual rainfall measurements
- Determine the supplemental water supply necessary for 1,800 square foot garden during spring planting season based on soil type and actual rainfall
- **Assumption:** Rows will be situated every 36-inches and plants will be spaced 1 to 2 feet apart within rows.

Design Appropriate Rainwater Collection Area and Storage:

- Determine roof collection surface area based on estimated irrigation needs and rainfall data.
- Design adequate storage to provide for drought periods

Determine agronomic productivity by crop type:

- Apply fertilizer based on soil sampling recommendations
- Weigh all harvested produce
- Determine the agronomic productivity for each crop based on lbs/plant and lbs/acre.

Students preparing beds and planting potatoes

Potato crop after six weeks of planting

Eggplant transplants

Table 1. Monthly rainfall averages from 1981-2010 at Gainesville Regional Airport compared with actual rainfall during 2017 spring planting season (inches)

Rainfall	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
30-yr Avg	3.20	4.33	2.67	2.48	7.12	6.07	6.39	32.26
Actual	0.38	0.47	3.38	4.00	17.11	10.20	5.30	40.83
Difference	-2.82	-3.86	+0.71	+1.52	+9.99	+4.13	-1.09	+8.57

Planting (Feb–Mar) | Harvesting (Apr–Aug)

Results

Table 2. Monthly Irrigation Demand

Dates	Crop water requirement (gal/month)	Rainfall (gal/month)	Supplemental irrigation (gal/month)
Feb 16-28	1568	417	1151
Mar	4407	522	3885
Apr	5651	3757	1894
May	6151	4453	1698
June	5502	19051	0 (-13549)
July	6245	11355	0 (-5110)
Aug	5718	5900	0 (-182)

Calculations & Assumptions:

- Crop water requirement = crop coefficient (0.85) x reference evapotranspiration (ETo) (obtained from Alachua FAWN station) [1,2]
- Water holding capacity for sandy soil – 0.75 inch/ft (correlates to 1700 gal/acre for 1-foot wetting depth for vegetable crop type planted)
- Number of irrigation events is dependent on daily ETo divided by application efficiency (60 to 80% for overhead sprinklers) [1,2]

 Example for Feb 16, 2017:
 Crop water requirement = (0.85)*(2172 gal/ac/day) = 1846 gal/ac/day
 Application efficiency = 1846 gal/ac/day/70% = 2637 gal/ac/day
 Number of irrigation events = 2637/1700 = 1.55 = 2 split applications
 so for 0.041 acres = 108 gal/day

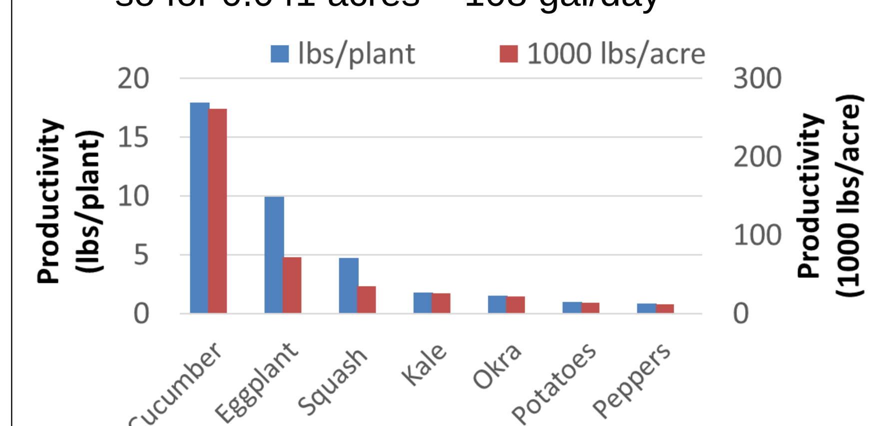

Figure 1. Agronomic Productivity by Crop

Conclusions

- Although rainfall total for the planting season exceeded the 30-year average, rainfall during critical establishment months was below average. Thus, design rainwater storage capacity needs to be a minimum of 4,000 gallons to accommodate drought conditions.
- Cucumbers (18 lbs/plant) had the highest crop productivity followed by eggplant (10 lbs/plant) and squash (5 lb/plant).

References

1. Zotarelli, L., Dukes, M.D., et al. (2016). Chapter 3. Principles and Practices of Irrigation Management for Vegetables. In: Dittmar, P. J., *Vegetable Production Handbook*. EDIS publication # CV297.
2. Florida Automated Weather Network, UF-IFAS, Report generated for Eto in Alachua, Florida. http://fawn.ifas.ufl.edu/data/reports/

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