Introduction to Aquaponics

GoFish Hawai‘i

1/14/2024

Overview

- **Meet Ted, Erik, Kai**
- **Introduction to aquaponics**
- **System design, water quality, food safety, management, fish health, species selection, and economics all coming soon!**

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Aqua-ponics

- **Hybridized name conflated from aquaculture and hydroponics**
- **Where do (most) aquaponicists come from:**
  - **Aquaculture?**
  - **Horticulture?**
- **Historically aquaponics was developed to minimize the environmental impact from aquaculture production systems and attempt to reuse and reduce the nutrients in the effluent waters**

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Aquaponics Definition

- EU Aquaponics HUB (Palm 2018):

‘Aquaponics is a production system of aquatic organisms and plants where **the majority (> 50%) of nutrients** sustaining the optimal plant growth derives from waste (effluent water, solid and sludge removal) originating from feeding the aquatic organisms’.

- Does it matter if you farm aquaponically by this strict definition of aquaponics? No! This distinction has been developed to market the products from aquaponics and develop the industry.

What is Aquaponics?

- **Aquaculture: farming of aquatic organisms under controlled conditions**

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U.S. Aquaculture

- **U.S. - $20 billion seafood trade deficit, WHY?**
- **High standards**
- **Competing against**
  - **Unregulated discharge**
  - **Indiscriminate use of antibiotics**
  - **Unregulated workforce**

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Hawai‘i Aquaculture

- **Import ~63% of seafood**
- **Diverse climate: 600,000 acres land + water and 140,000 acres coastal lands (mariculture)**
- **Multiple micro-climates with potential to grow virtually anything**

Hawai‘i Aquaculture 2000

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Hawai‘i Aquaculture 2024

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Blue Ocean MARICULTURE

cellana
algae-based products for a sustainable future

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INDO-PACIFIC SEA FARMS
Captive-Bred Marine Life for Healthier Reef Aquariums

KAMPACHI FARMS, LLC
OCEAN CULTURE, NATURALLY

Kona Coast Shellfish LLC

KONA COLD LOBSTERS LTD

Mera Pharmaceuticals
Bringing the Ocean to Life

ROYAL HAWAIIAN SEA FARMS

MOANA Marine Biotech

Pacific Planktonics

Shrimp Improvement Systems Hawaii LLC

Taylor Shellfish Farms
www.TaylorShellfishFarms.com

TROUTLODGE MARINE FARMS

Sea Grant University of Hawai‘i

Hawai‘i Aquaculture

Current

- **Abalone**
- **Catfish (Clarius fuscus)**
- **Freshwater ornamental fish and aquatic plants (various species)**
- **Broodstock and juvenile shrimp**
- **Kahala (amberjack)**
- **Marine ornamental fish and plants (various species)**
- **Marine shrimp for food (Penaeus vannamei)**
- **Microalgae (Spirulina sp., Hematococcus sp.)**
- **Seahorses (various species)**
- **Seaweed or sea vegetables (Gracilaria sp.)**
- **Seed clams (Mercenaria mercenaria)**
- **Seed oysters and clams**
- **Tilapia (Tilapia sp.)**

Research

- **Deepwater snappers (opakapaka, ehu, onaga)**
- **Groupers (various species)**
- **Halibut**
- **Jacks (various species)**
- **Live rock**
- **Marine ornamental fish (various species)**
- **Marine ornamental invertebrates (various species)**
- **Sable fish**
- **Sturgeon (various species)**
- **Tilapia**

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Hawaii Aquaculture
Value of Sales, 2003 – 2022

* 2013 and 2018 values were collected by the Census of Aquaculture. To access, see link below.

https://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Census_of_Aquaculture/index.php

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Department of Agriculture STATE OF HAWAII

Hawai‘i Aquaculture

- Total revenue: $89.6 million, up 12% from 2021 (pandemic shipping/labor issues)
- Algae 46%-pharmaceutical
- Ornamentals 5%-(SW) seahorse, live rock, FW
- Other 48%-SPF shrimp, abalone

- Hawai‘i ranks 6th in sales of aquaculture products (US)
- Total number of farms: 45
  - Food fish 23
- Hawai‘i residents annually eat 37 lbs of fish per person (double national)

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Feed Efficiency in Fish

- **Feed use efficiency**
- **Feed conversion ratio (FCR)**
  - **How many pounds of feed it takes to make one pound of fish**
- **Example: 100 lbs of feed resulted in 50 lbs of tilapia at harvest 100/50= FCR 2.0**

Stock	FCR	Efficiency
Sheep	8:1	12.5%
Cattle	6:1	16.6%
Hogs	4:1	25.0%
Poultry	3:1	33.3%
Tilapia	2: 1	50.0%
Salmon	1.2:1	83.3%

http://en.wikipedia.org/wiki/Feed_conversion_ratio

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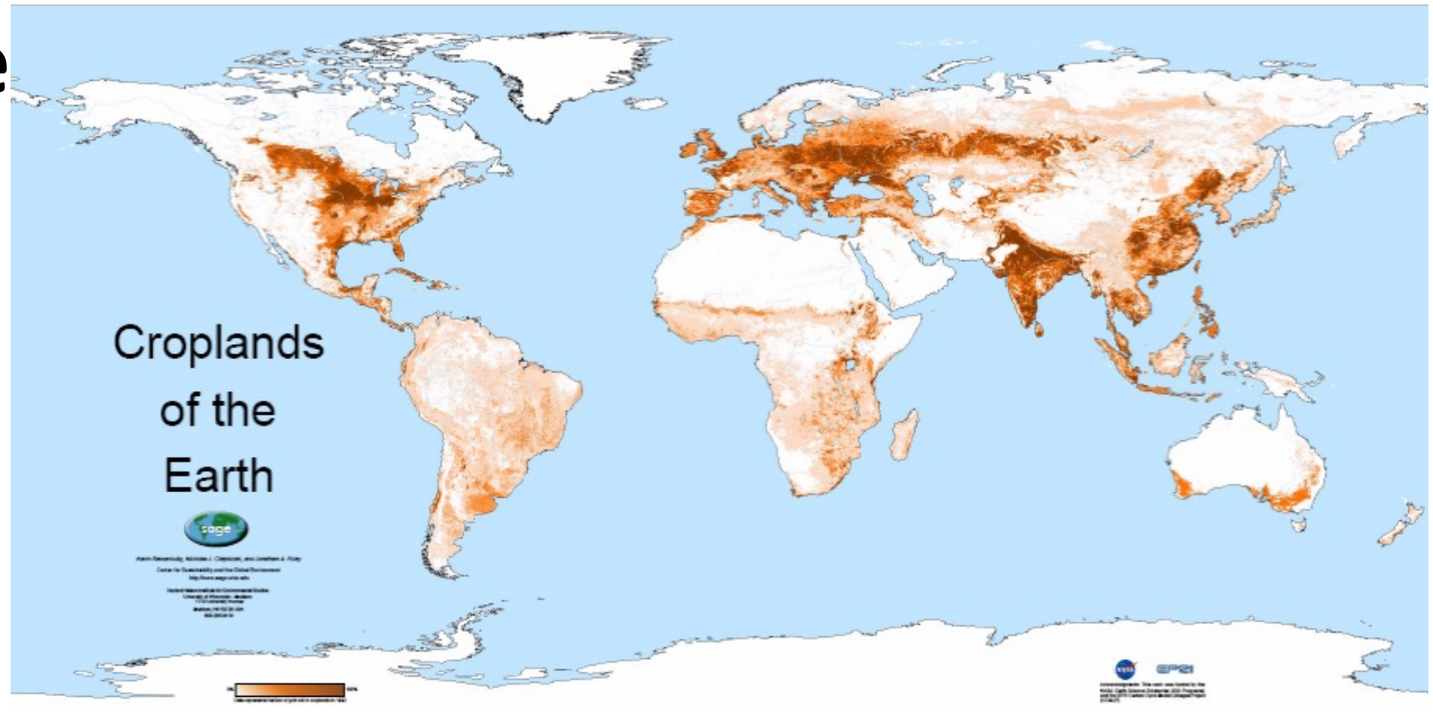
Quantity of Available Land

- **Croplands and pasture are largest terrestrial biome**
- **Cover 40% of Earth's surface**
- **Need to freeze agriculture's footprint and intensify production**



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Land Use Efficiency (RAS)

- **Modern aquaculture (intensive)**
  - **High density, biomass**
  - **Artificial environment**
  - **Large energetic input**
- **Recirculating aquaculture system (RAS)**
  - **Water re-used**
  - **Biofiltration**
  - **Can be paired with plants (FW)**

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What is Aquaponics?

- **Hydroponics: Technique of growing plants (without soil) in water containing dissolved nutrients**

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What is Aquaponics?

- **It is not a technique or a type of hydroponics that uses fish as a source of nutrients**
- **It is a conceptual design based on synergistic relationships between its components (agricultural production system)**
- **It can utilize many different techniques**
- **Ignoring this can lead to wrong designs, excessive complexity and waste of resources**
- **Interactions between microbial, fish and plants component in mature aquaponics system result in synergistic effect and increase in production (think of it as an ecosystem)**

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Why Aquaponics?

- **Sustainable and intensive**
- **Two crops from one fertilizer source**
- **Water efficiency**
- **No soil, pesticides**
- **High yields, control of production**
- **Organically-grown (certified)**
- **Soil-less (no contaminants)**
- **Small footprint, use non-arable land**
- **Can be built ergonomically**
- **Can be scaled, and material/information widely-available**

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Challenges in Modern Agriculture

- **Water: ~80%**
- **Fossil fuels: ~18%**
  - **Machinery**
  - **Processing**
  - **Refrigeration**
  - **Packing**
  - **Transport**
  - **Fertilizers**
    - **(~3 cal of fuel for 1 cal food)**
  - **Pesticides**
- **Pollution**

https://www.google.com/search?q=conventional+agriculture&source=lnms&tbm=isch&sa=X&ved=2ahUKEwiFuZqE3_HsAhWzMn0KHQ3oD48Q_AUoAXoECBgQAw&biw=1373&bih=628#imgrc=dG345s9K2s6YDM&imgdii=wUwsqSFLlnVb2M

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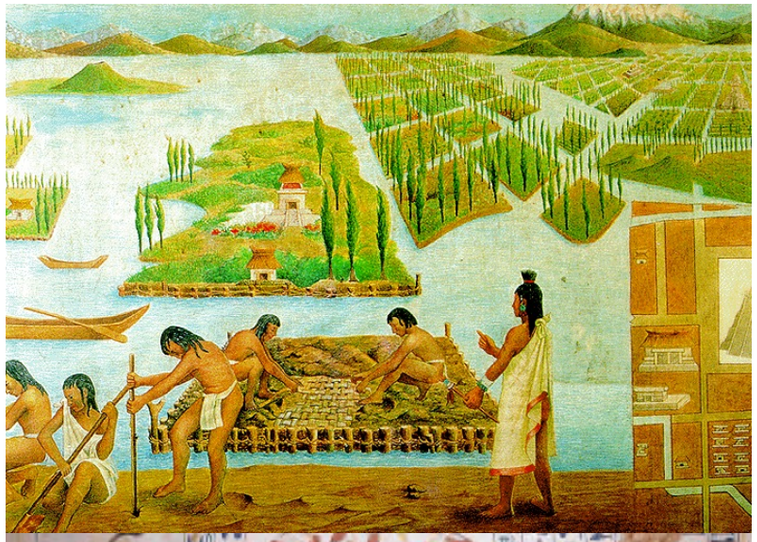
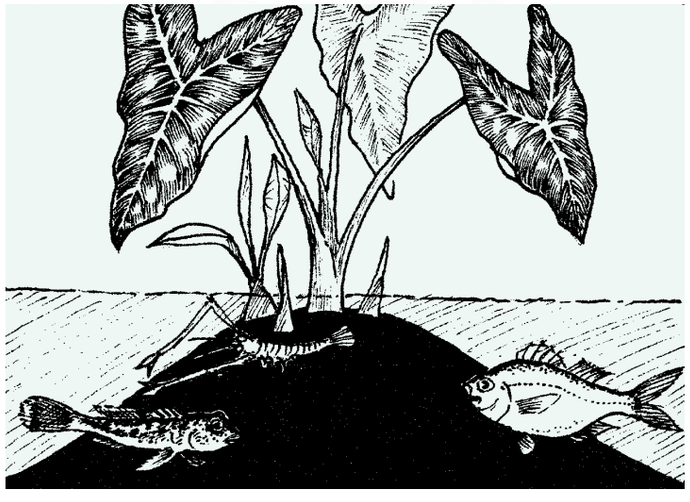
Integrated Agriculture is Ancient





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Brief History of Aquaponics

- **Hydroponics: Gericke 1929**
  - **Chemical salts in water**
- **US Military (WWII)**
  - **Industrialization, plastics, greenhouse**
- **New Alchemy (1970s)**
  - **Single-pass (no biofilter)**
  - **RAS/vegetables**
- **Commercial scale**
  - **McMurty (1980s-90s)**
  - **Rakocy (2000s)**

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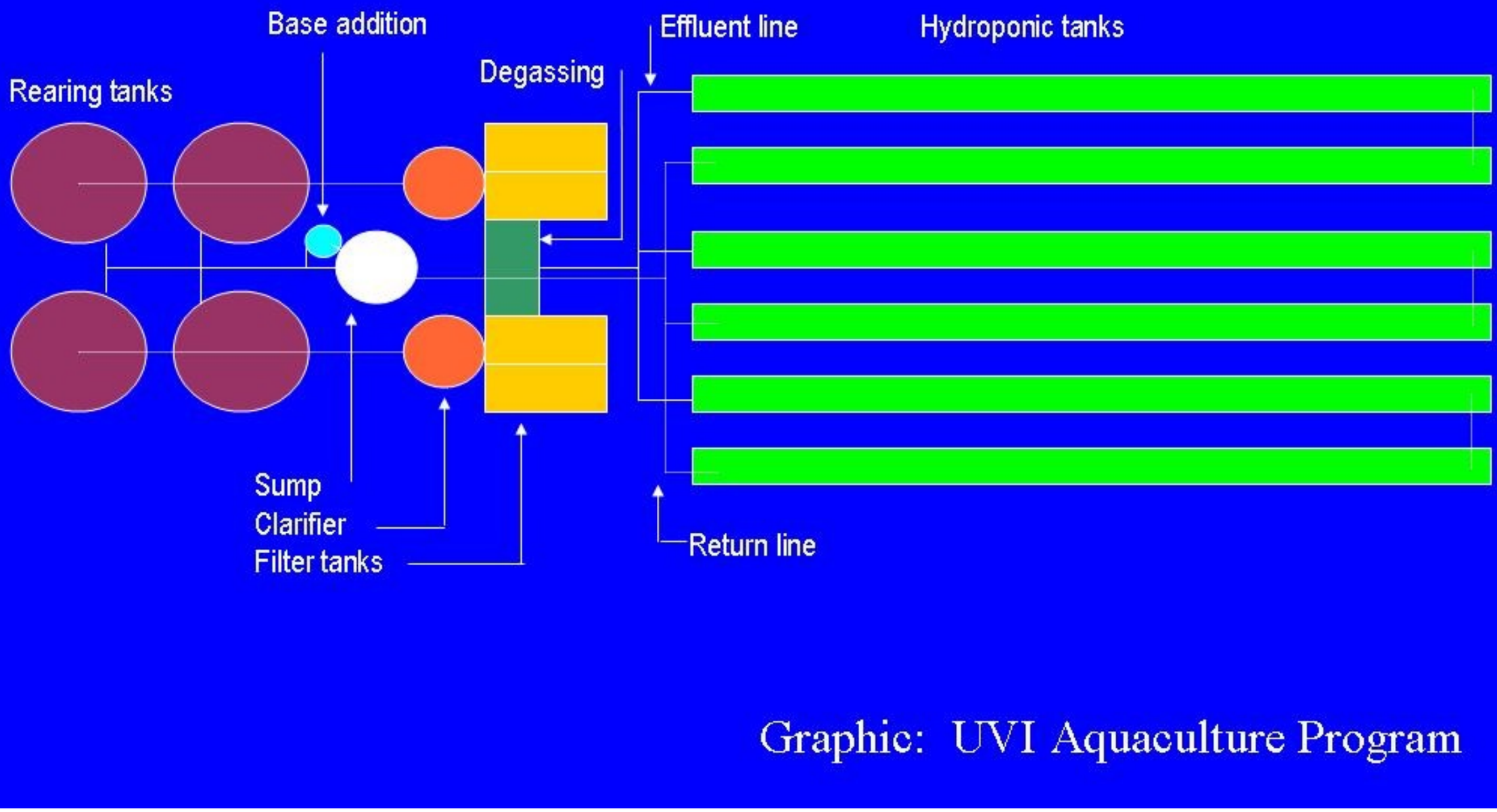
UVI Aquaponic System



Graphic: UVI Aquaculture Program

http://www.uvi.edu/research/agricultural-experiment-station/aquaculture-home/aquaponic-systems/default.aspx

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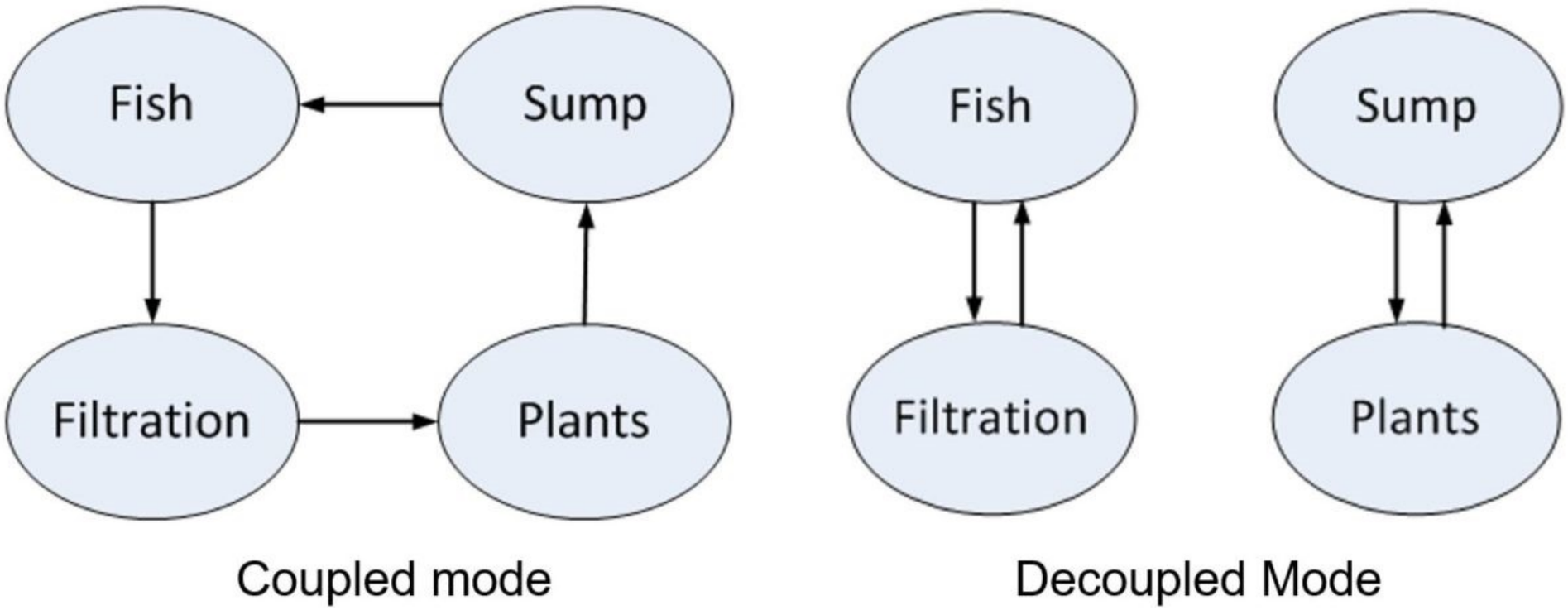
The modern aquaponic operation should be:

- **Robust**
- **Reliable**
- **Simple**
- **Easy to operate**
- **Requiring minimal labor**
- **Low risk**

System Design



https://www.theaquaponicsource.com/aquaponic-system-decoupling/

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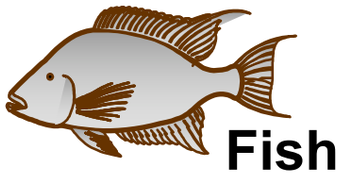
Nitrogen Transformation in an Aquaponic System



Fish

(excretes)

Ammonia (NH_3)

www.vedicsciencesnet

(*Nitrosoma spp.*)

Nitrite (NO_2)

www.gopaultech.com

(*Nitrobacter spp.*)

Nitrate (NO_3)

(uptake)

Plant

(water returns)

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System Design:Types of Aquaponic Systems

- **Ebb and flow (reciprocating)**
  - **Hydroponic support media (gravel, clay balls, cinder, etc.) “box of rocks”**
- **Raft aquaponics**
  - **Polystyrene sheets**
- **Nutrient Film Technique (NFT)**
  - **Rain Gutters**
  - **PVC pipe**
- **Three Components**
  - **Rearing tank**
  - **Biofilter**
  - **Hydroponic component**

www.selfsufficientlife.net/category/aquaponics/

UVI

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Biofilter Consists of Two Components

- **Biological Filtration**
  - **Bacteria need some type of media to cling to in order to complete nitrification process (biofilm)**
  - **The more surface, the more efficient the process**
  - **Examples of biological filtration media:**
    - **Matala mats**
    - **Kaldnes Media**
    - **Pea Gravel**
    - **Lava Rock**
- **Mechanical Filtration**
  - **Solids must be removed from the system**
  - **Examples of biological filtration media:**
    - **Circulation Pumps**
    - **Swirl separators**
    - **Drum Filters**
    - **Filter Socks**
    - **Cleaning of media beds**

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Most Basic Design

Submersible Pump inside of fish tank

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Aquaponic Research Needs

- **Study of various production systems**
- **New fish species into aquaponics**
- **Nutrient cycling**
- **Economic and marketing analysis**
- **Fish feed in aquaponics**
- **Addition of solid waste treatment loop**
- **Anaerobic vs. aerobic sludge treatment**
- **Influence of the aquaponic waste onto the plant performance in comparison to regular farming practices**
- **Food safety studies**
- **Aquaponics microbiome studies**
- **Balance studies and modelling of aquaponic systems**
- **More predictability commercial commercial operations**
- **Development of new methods for water filtration**
- **New scientifically-based designs for commercial aquaponics of small, mid- and large sizes**
- **Economic studies using aquaponic systems based on modern technologies as opposite to backyard aquaponics**
- **PGPM (plant growth promoting microbes)**

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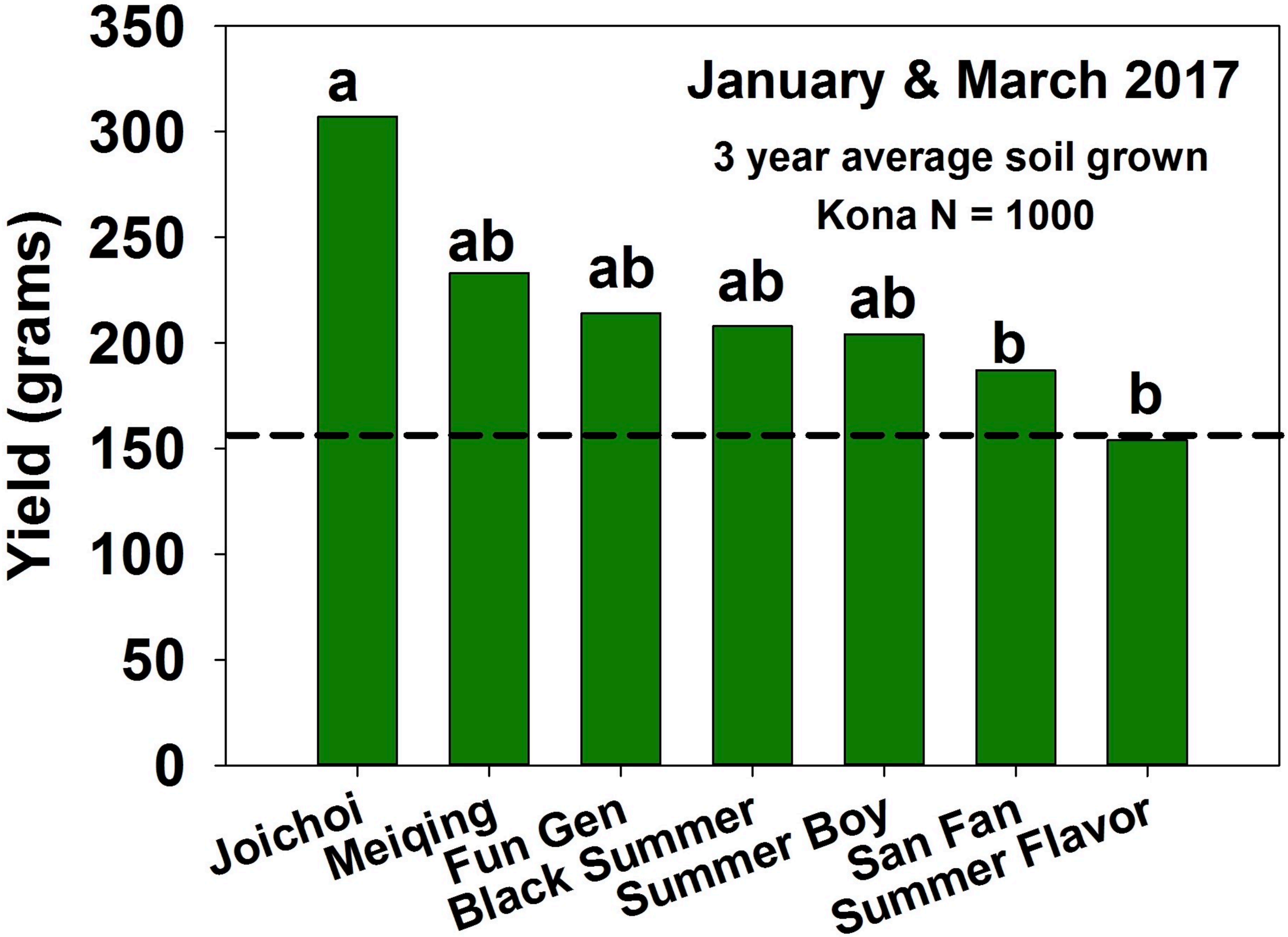
Fun Jen
Black Summe
Mei Qing


January & March 2017
3 year average soil grown
Kona N = 1000
Yield (grams)
350
300
250
200
150
100
50
0
a
ab
ab
ab
ab
b
b
Joichoi
Meiqing
Fun Gen
Black Summer
Summer Boy
San Fan
Summer Flavor


A2
B3
C2
7
3


C3


14
rep C
4/25