

Indoor Shrimp Farming Systems in the U.S.



COLLEGE OF
AGRICULTURE,
COMMUNITY, AND
THE SCIENCES



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National Institute of Food and Agriculture

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Why Grow Shrimp Indoors?

- Can be Located Anywhere... Warm, Salt Water Animal
 - Close to Markets
 - Away from the Coast... Even in FL
 - Reused Infrastructure
- Control
 - Consistent Conditions = Predict Results
 - Fresh, Never-Frozen
 - Large Shrimp = Higher Sale Price
 - Any Time of the Year



Recirculating Aquaculture Systems (RAS)

- “Indoor?”
conserve water
and heat
 - Insulated Buildings
 - Greenhouses
 - Hybrid Buildings
– framed with windows



Black Iris Farms, Ann Arbor, MI



Insulated Space = Year-Round Production in Cool Climates



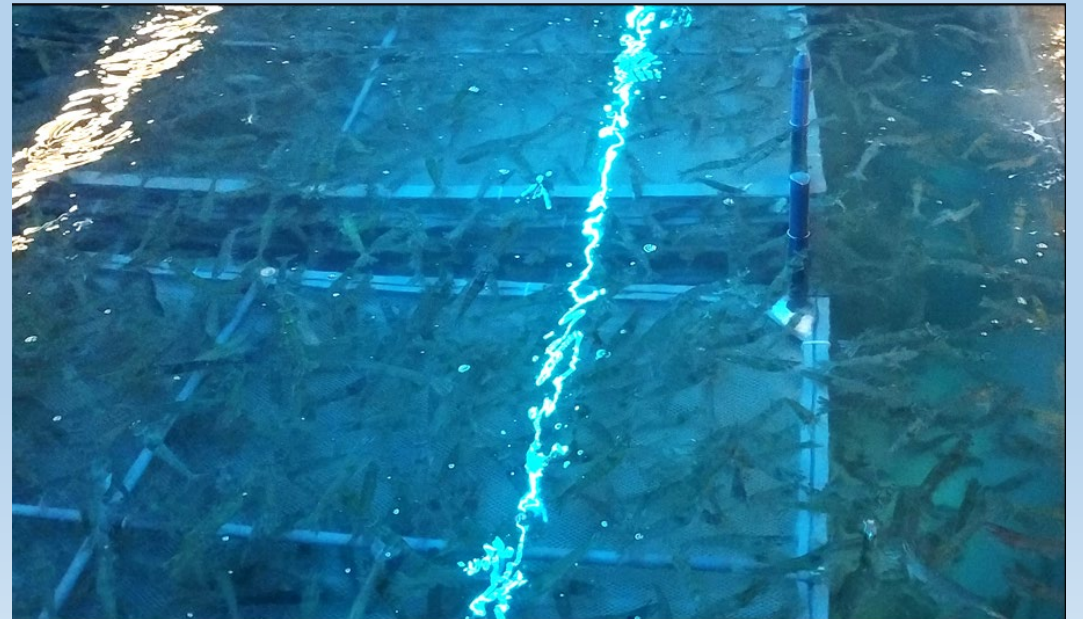
Shrimp in RAS

- Clear-water
 - Less common for now
 - High level of control, Mechanical complexity
 - Reduced disease
 - Higher density... better optics?
- Biofloc
 - Rely on microbes in water for biofiltration
 - Biological complexity – Vibrio?
- Hybrid
 - More filtration but plenty of microbes in the water
 - A working model for small to medium scale farms

TrasparentSea, Downy, CA



Forde Garlenen, Germany



Farm Locations by State

Florida	6
Iowa	3
Wisconsin	3
Montana	3
Kentucky	2
Ohio	2
Hawaii	1
Illinois	1
Missouri	1
Texas	1
Minnesota	1
Indiana	1
Wyoming	1
Colorado	1
Georgia	1
New Hampshire	1
Nebraska	1

U.S. Shrimp Farm Survey

- KSU and USDA-APHIS
- 31 Refusals and 36 Completions
→ 54% Response Rate

Time Spent Farming Shrimp

<u>Time Frame</u>	<u>Frequency</u>	<u>%</u>
Less than 1 year	1	3.3
1 - 5 years	13	43.3
5 - 10 years	8	26.6
10 - 20 years	4	13.3
More than 20 years	4	13.3

Reason for Farming Shrimp

- 90% Food Shrimp
- 23% Post Larvae
- 20% Brood Stock
- 13% Bait Shrimp
- 0% Ornamental

U.S. Shrimp Systems

- 52% Biofloc
- 26% Hybrid – Biofloc RAS
- 7% Clear Water RAS
- 7% Flow Through

- 19% Outdoors
- 33% Greenhouse
- 22% Closed, Uninsulated Building
- 60% Closed Insulated Building
- 11% A combination of These

- 37% Swimming Pools
- 15% Wood-Framed Tanks
- 19% Concrete Tanks
- 15% Plastic/Manufactured
- 15% Ponds
- 4% Dug Raceways
- 37% Above-Ground Raceways



Biofloc

- Not many success stories in the U.S.
- Many small farms out of business
- Very low survival
- Need efficient aeration... maybe oxygen

Homegrown Shrimp... this IS a success story



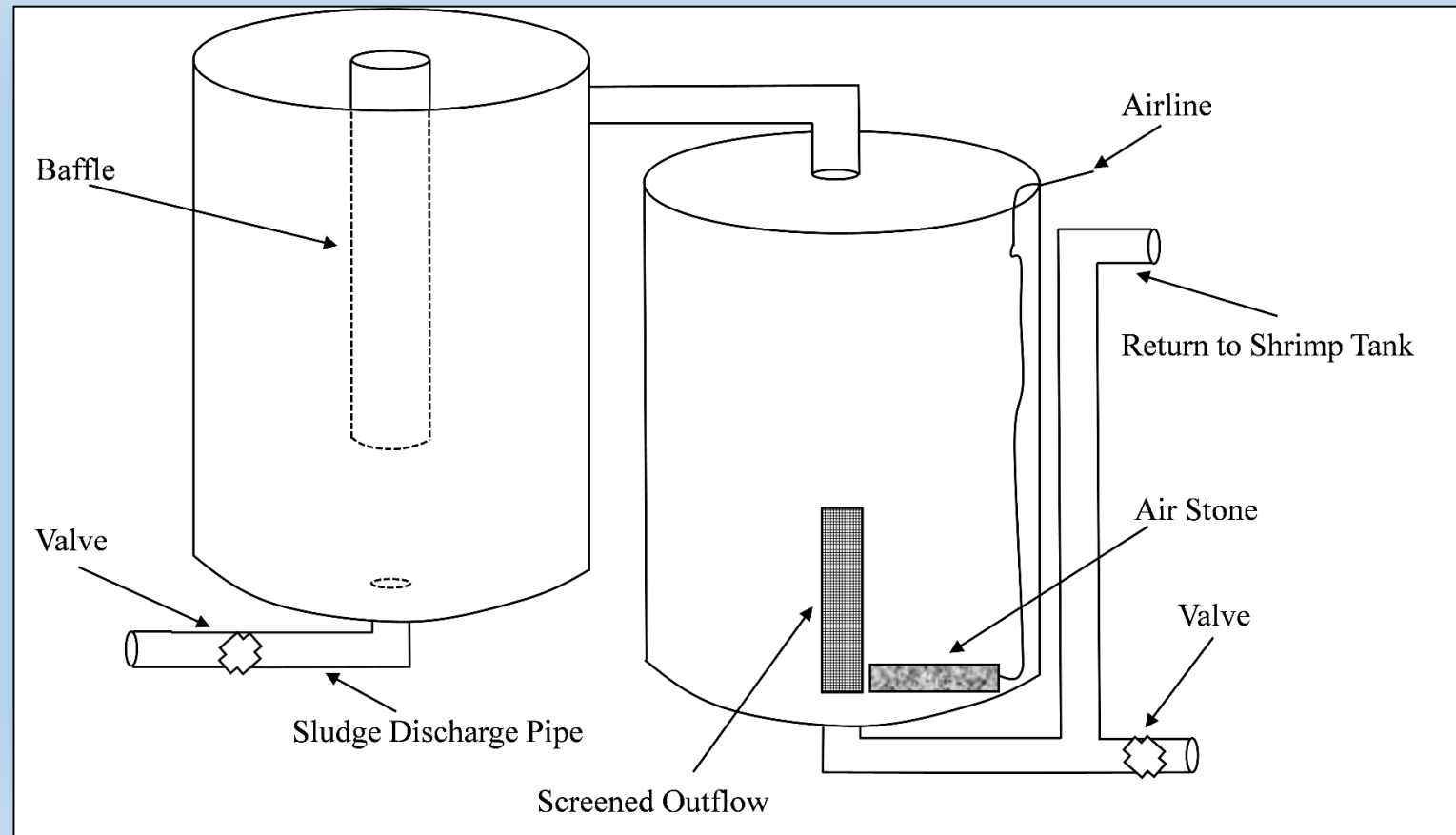
Hybrid Systems

- Seem to be a Good Option for Those with Limited Aquaculture Experience
- Home-Made Filters for Small or Large-Scale Farms
- Settling Chambers
 - Large Particles
- Fractionators
 - Small Particles
- Biofilter



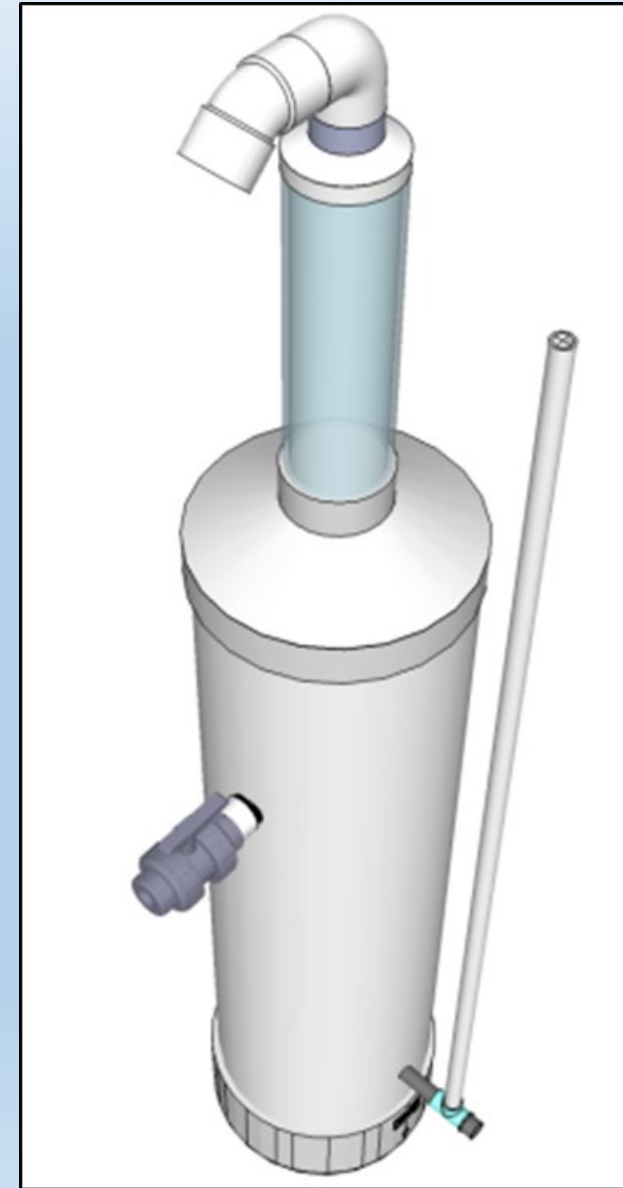
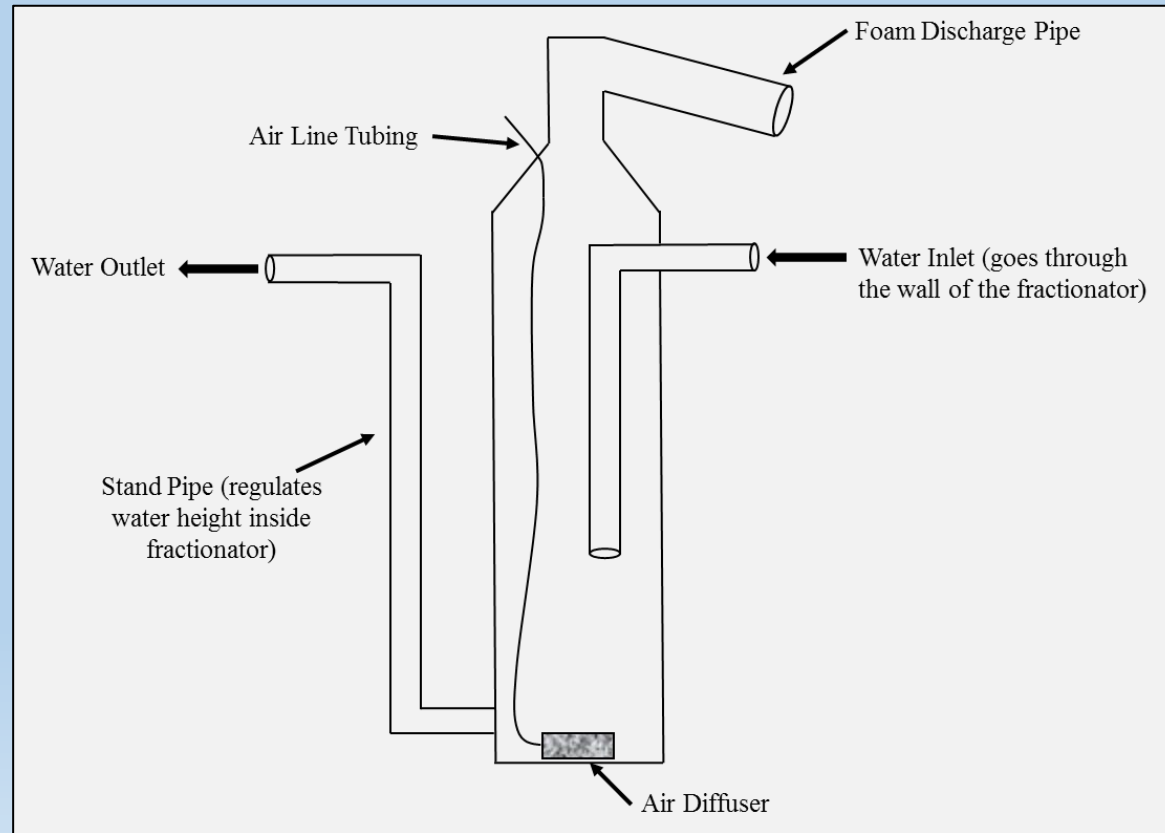
Filter Setup – Settling Chamber and Biofilter

- Moving bed bioreactor
 - Nitrification
 - Denitrification



Home-Made Fractionators to Strip Solids

- Remove smaller/ dissolved particles
- Vibrio? Crank this up!



Clearwater Systems

- Clearwater and near zero discharge...
 - Drum Filter?
 - Fractionator
 - Ozone
 - UV?
 - Nitrifying MBBR
 - Denitrifying MBBR
 - Oxygen...
- Customers? Clean Product



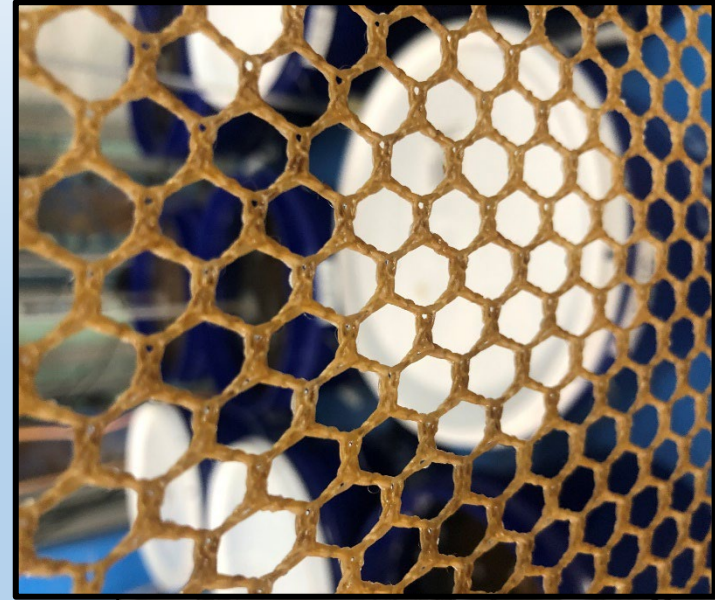
Artificial Substrate... Optimizing Space

- Shrimp can graze and rest, microbes grow – food and biofiltration
- Cannibalism, better utilization of entire water column
- Vertical substrate... studied for decades
- Research with horizontal substrate lacking
- German shrimp farm Forde Garlenen
 - <https://www.youtube.com/watch?v=FMJL-1EqlUc&t=1348s>
 - 25 kg/m³ ???



Hybrid vs. Clearwater and Substrate vs. None

- 2 factors with 2 levels, 1 m³ tanks
- System type: Clear-water (CW) and Hybrid (HY)
- With (WS) and no substrate (NS)
- CW-WS, CW-NS, HY-WS, and HY-NS (4 treatments, 4 replicates)
- Stocked at 450 shrimp per tank
- Hole dimensions of 10mm * 4mm
 - dispersion of air bubbles and feed



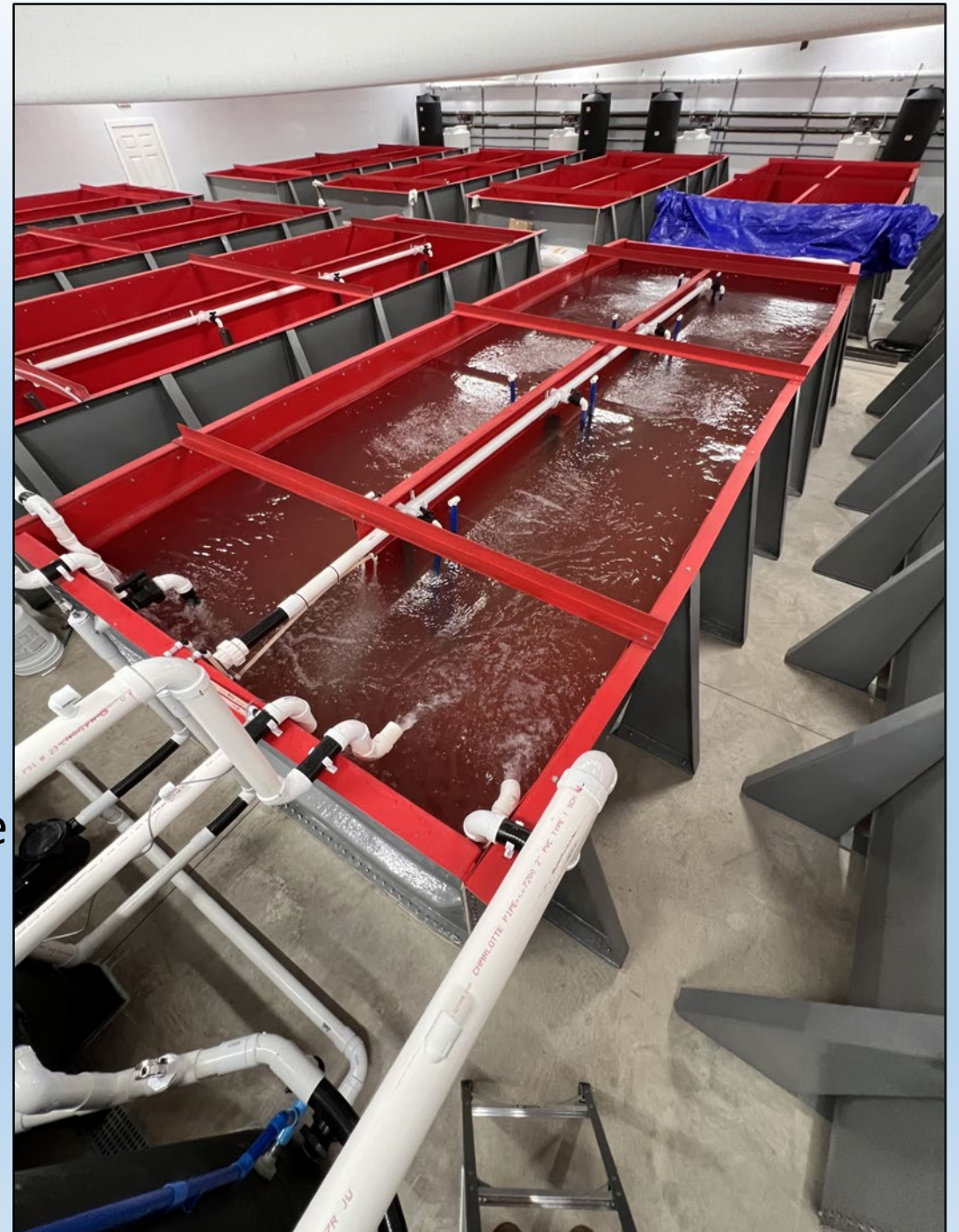
Results

- We killed our biofilters with ozone... high ammonia, nitrite, etc...
- Clearwater tanks with substrate did okay. Substrate = biofiltration!
- Hybrid systems did amazing with substrate! Limited by... Oxygen

Treatments	Average Wt. (g)	Total harvest (Kgm⁻³)	Survival (%)	FCR	Growth rate (g/week)
HYWS	18.2 ^a	7.0 ^a	86.0 ^a	1.2	2.3 ^a
HYNS	14.7 ^{bc}	4.8 ^{ab}	73.0 ^{ab}	1.9	1.8 ^{bc}
CWWS	17.3 ^{ab}	5.7 ^{ab}	74.0 ^{ab}	1.7	2.2 ^{ab}
CWNS	13.6 ^c	2.7 ^b	44.0 ^c	3.7	1.6 ^c

Clear Water Opportunities

- 25 – 30 kg/m³ – more?
- Clean Appearance... customers, investors
- Home-made filters... ozone?
- Horizontal substrate – removable
- Less disease risk?
- A.I.
 - Acoustic Data
 - Visual Data – Behavior, uneaten feed, Disease
 - Water Quality – Tons of Data
 - Precision Feeding
 - Automation – VFD, O₂ use, Lighting, Filters
 - Train it to do “anything?”
 - Open valves, adjust flow for gas and water



Issue: Artificial Salts

- Full Sea Salt is Expensive
- Could Discharge More Water if Needed With Cheaper Salt
- Off-the-shelf Versus Home-Made
 - Less than half the cost
 - Same production levels

15 g/L Salt Solution @ 1m ³	
NaCl	11,310 (g)
MgSO ₄	1,830 (g)
MgCl ₂	855 (g)
CaCl ₂	376 (g)
KCl	240 (g)
NaHCO ₃	90 (g)



Saltwater Aquaponics

- A variety of halophyte and non-halophytes, macroalgae
- Kale tastes great at 15 ppt. salinity!
- Grows a little slower as salinity increases



Kale 0ppt



Kale 10ppt



Kale 15ppt



Kale 20ppt

So... what system do I use?

- Plenty of options
- Production goals
- Discharge goals
- Customer requirements
- Risk adversity
- Capital investment
- Each farm is unique!



Thank You!

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 - Online courses
 - Certificate program
 - Social media
 - Wide range of expertise

