New Developments in Sustainable Agriculture: Aquaponics and Beyond

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For **"Economic Impacts: Perspectives on Trends in Agriculture, the Environment and Society"**

The joint conference of The Alberta Agricultural Economics Association (AAEA) and The Resource Economics and Environmental Sociology Student Association (REESSA).

April 30, 2015,

Red Deer, Alberta

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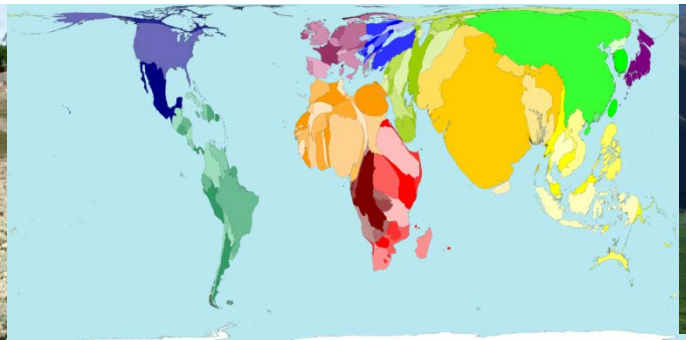
Challenges of World Agriculture

- Limited resources
- Environmental impact
- Water management
- Nutrient management
- High energy input
- Economic sustainability
- Existing markets are near to saturation in Europe and North America

- Nitrogen synthetic fertilizers are currently produced using non-renewable fossil fuel, such as natural gas.

- According to the most recent survey by the International Fertilizer Development Centre (IFDC), 85 percent of all phosphorus rock reserves on the planet are located just in one area: in Morocco and Western Sahara.

The major challenge of agriculture in Alberta is to improve its sustainability while staying competitive

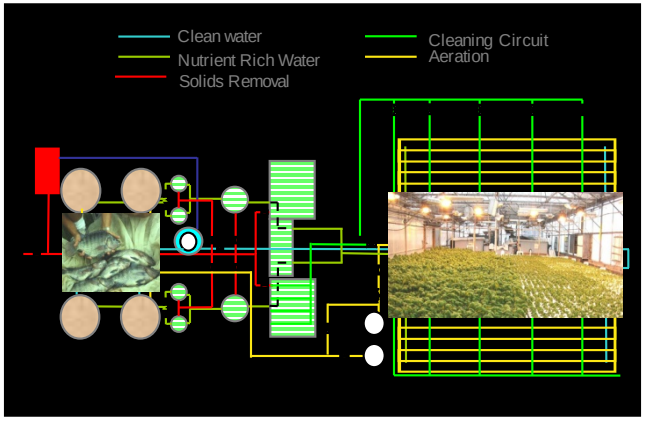
How we can address those challenges? Is there “magic bullet”, which will make agriculture more sustainable in 21st century?

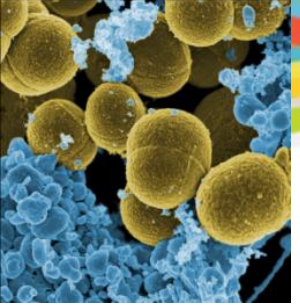
In not so distant future, we may need to change the existing agricultural paradigm to produce food more sustainably. Intensive integrated farms based on modern technology, such as aquaponics, can be a viable solution.




What is aquaponics?

*Aqua*culture + Hydro*ponics* = *Aquaponics*





The Basic Process:

- Fish produces waste;
- Microorganisms convert the waste into soluble nutrients available for plants;
- Plants utilize soluble salts regenerating water for fish production.

All organic waste is utilized by the system itself

Advantages of aquaponics

- Nutrient and water recycling
- Minimal environmental impact
- Multiple revenues

Aquaponics Project at Crop Diversification Centre South, Brooks, Alberta – started in 2002

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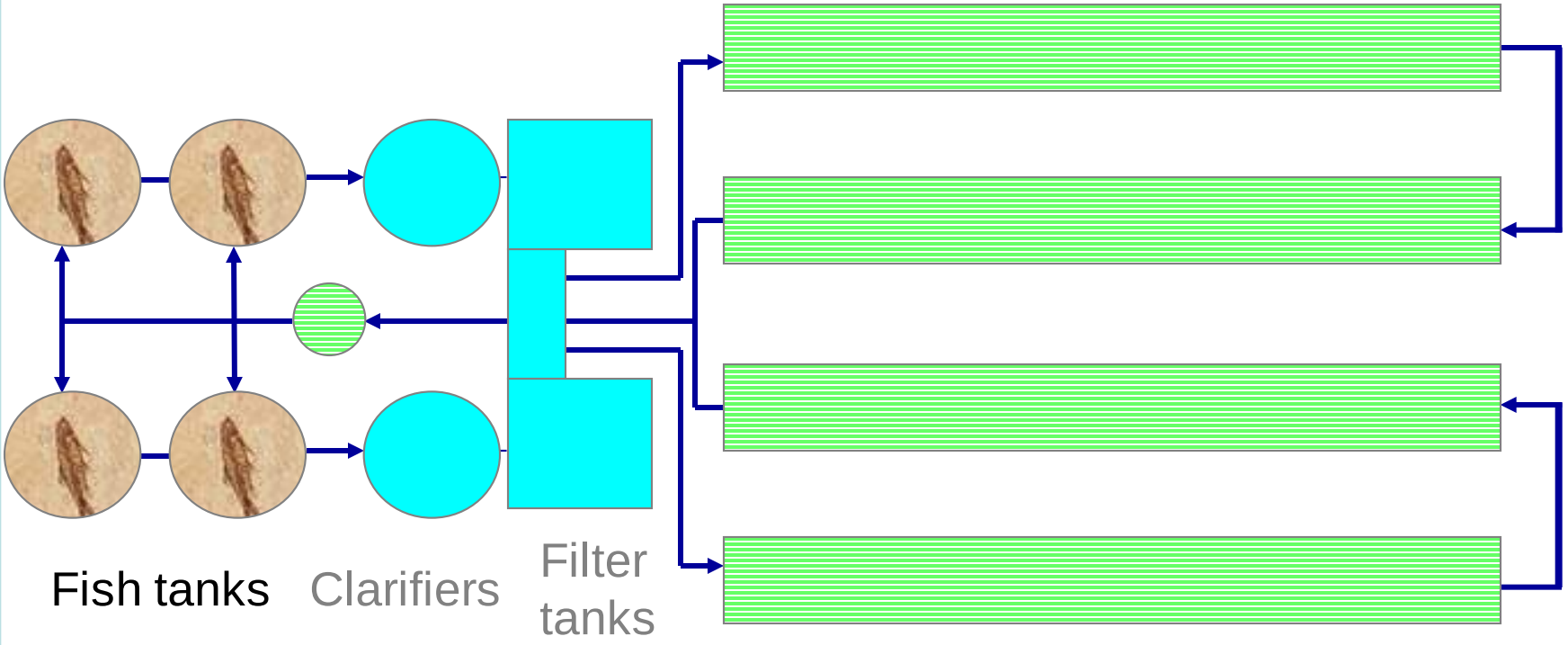
The objectives of this study were:

- Technical feasibility
- Food safety
- Economic feasibility

Brooks Aquaponics Facility is based on the Model developed in University of Virgin Island



Tilapia was selected the species selected

Nile tilapia

Red (hybrid) tilapia

Over 60 different crops have been tested in Brooks since 2002.

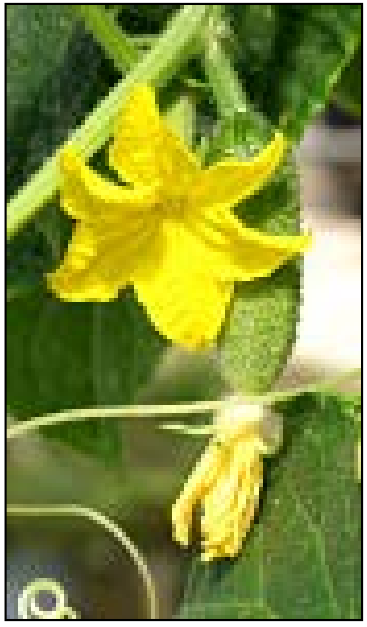
Plant choices

Unlimited - depends on consumer markets, geographic location, temperatures, pest resistance and nutrient uptake

Plant types

- Greens
- Flowers
- Medicinals
- Herbs
- Vine crops
- Aquatics

Cucumber crop CDC South, Brooks, Alberta



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Tomatoes in Brooks Aquaponic Facility (BAF)


Tomatoes

Bitter melon

Herbs

Living basil

Chives

Cut basil

Parsley

Parameters of the pilot-scale system in Brooks, Alberta

- Total volume – 73 m^3
- Plant area – 84 m^2
- Flow rate – 700 L min^{-1}
- Fish production capacity – 3.7 tons $year^{-1}$
- Basil crop production – 3.5 tons $year^{-1}$

The project resulted to Generation 4 design: a new type of integrated farming using state-of-the-art technology in fish production, waste treatment and soilless production

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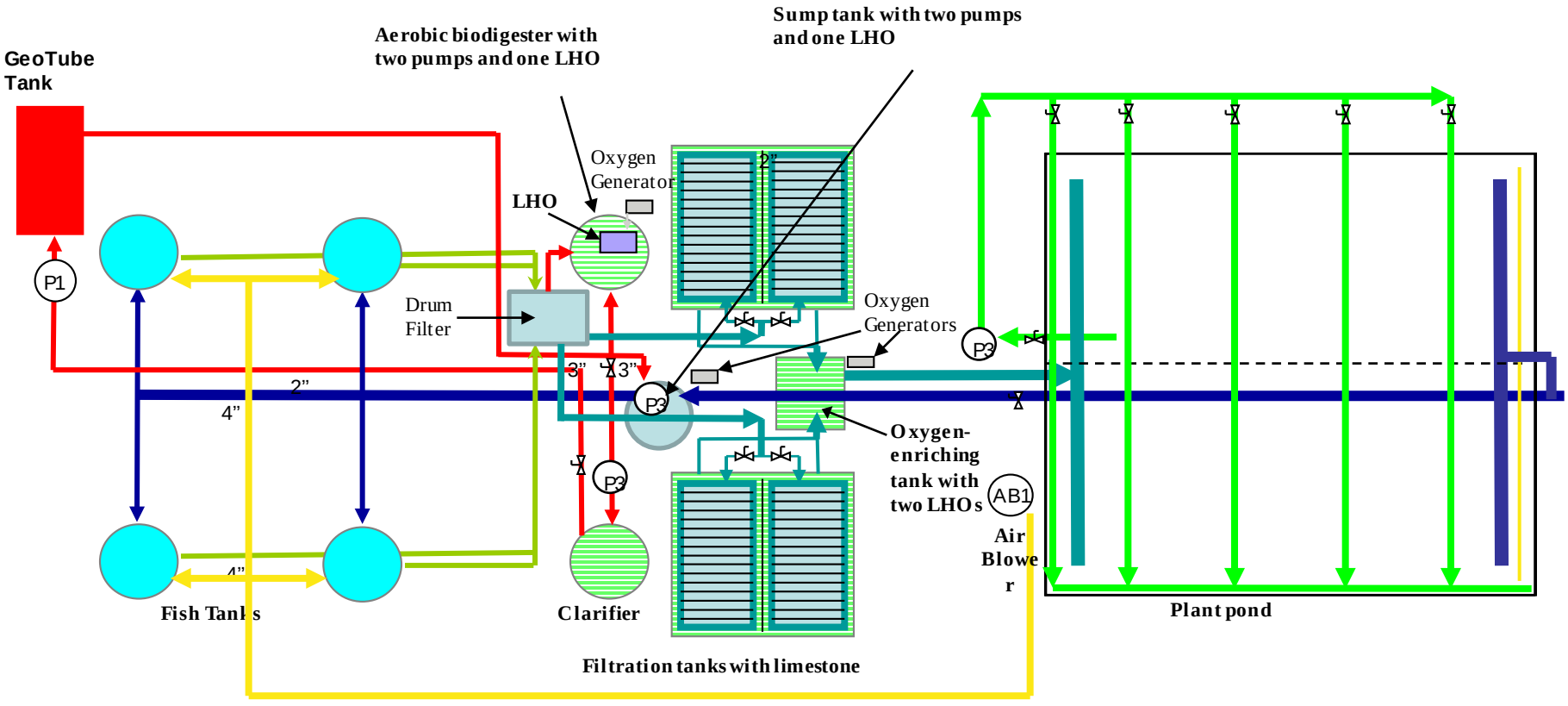
Layout of a Generation 4 aquaponics system



Clean water

Nutrient Rich Water

Solids Removal Circute

Cleaning Circuit

Aeration

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Water has been recirculated for 12.5 years without discharge.

No accumulation of sodium or toxic compounds has been observed in the water

Plant growth stimulating effect in integrated fish/plant production system has been reported for the first time.

Rosemary roots

Hydroponics

Aquaponics

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Enhanced growth of basil in Brooks aquaponic facility

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Effect of aquaponics water on basil production. Commercial trials at Red Hat Co-operative Ltd , April 18, 2013

4-week old aquaponic plants

6-week old hydroponic plants

Economic Analysis Of Aquaponics Operations In Canada based on Generation 1 (UVI) Model

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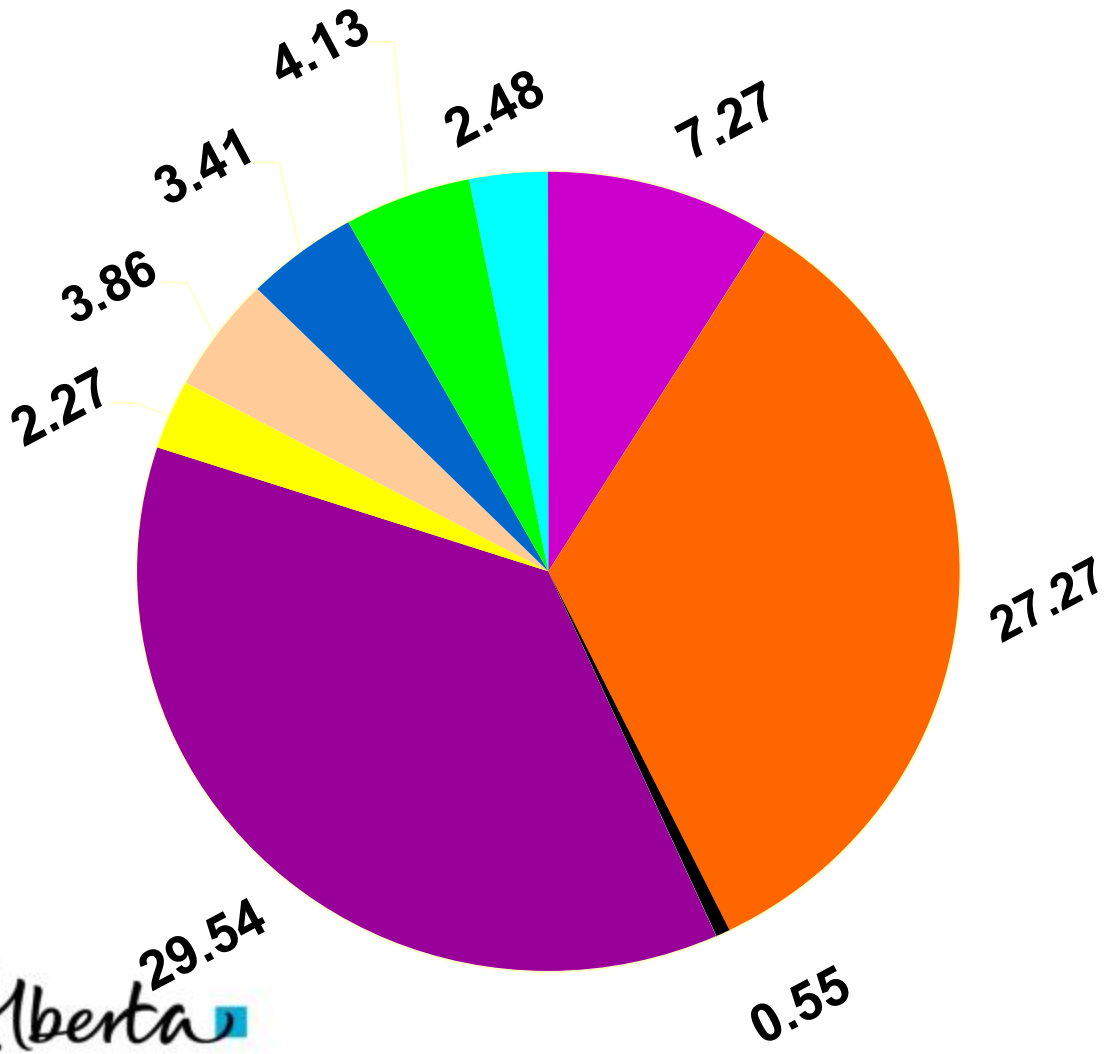
Tilapia production

- Area for Tilapia production = 1,000m^2
- Tank size = 32 tanks – 10 feet round
- Tilapia production per year = 36 tonnes
- Tilapia price = $6.50 to $9 per kg.
- Fingerling price includes allowance for mortality.
  - Tilapia Revenue
  - 36 tonnes annually
  - Sold at $7.50 per kg.
  - = $270,000 per year

Tilapia production (%)



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Aquaponics basil production

- Greenhouse area for basil production = 4,000m^2
- Number of basil crop harvests per year = 52
- Yield per m^2 = 12.5 kg.
- Revenue per m^2 = $135

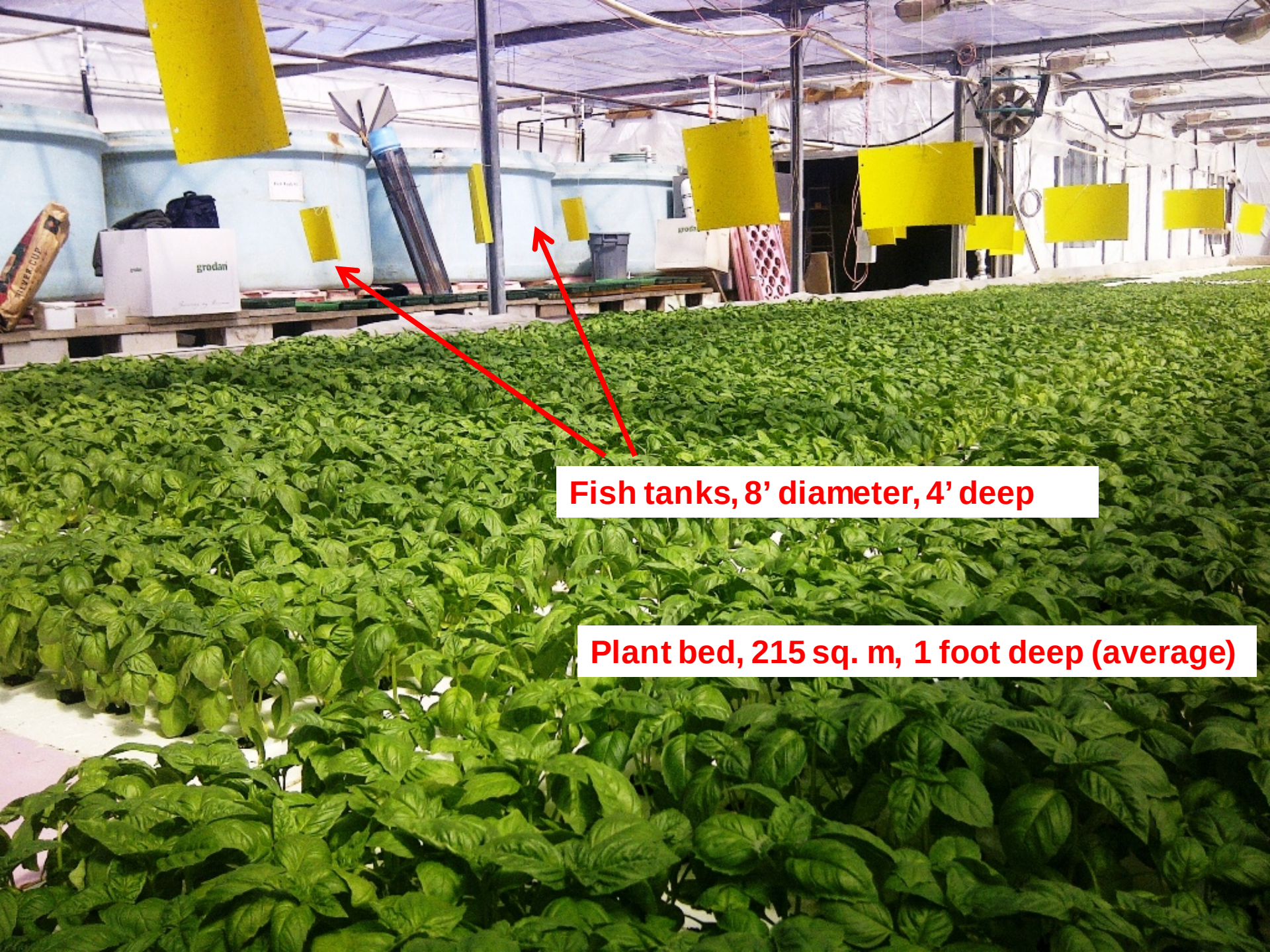
Costs and returns for Tilapia and basil production

	Tilapia	Basil	Total
Sales ($)	270,000	540,000	810,000
Operating costs ($)	204,325	348,950	553,275
Capital costs ($)	15,735	46,320	62,055
Production costs ($)	220,060	395,270	615,330
Gross margin ($)	66,675	191,050	257,725
Return to equity ($)	49,940	144,730	194,670

Examples of Commercial G4 Aquaponics Systems in Canada

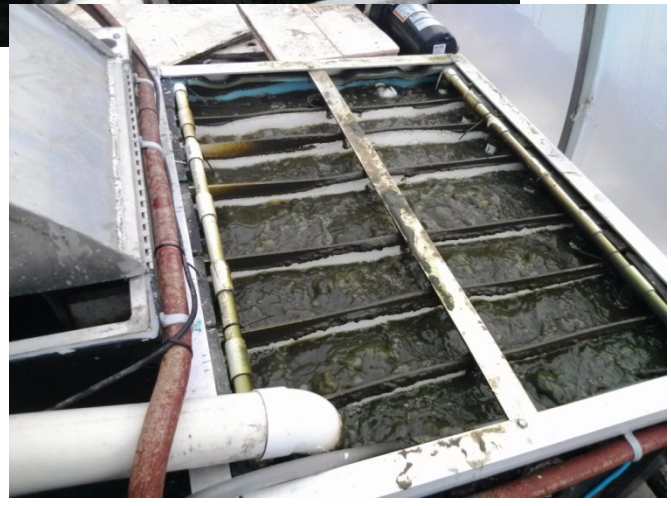
- Red Hat Co-operative, Redcliff, Alberta


Handy Polaris
33.6 mg/L
23.7 °C
436 %SAT
Esc
OK
www.oxyguard.dk
OxyGuard


Fish tanks, 8’ diameter, 4’ deep
Plant bed, 215 sq. m, 1 foot deep (average)

Aquaponic cucumbers

MDM Aquafarms, Alberta



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Northern Bioponics, British Columbia


HYDROTECH

- Aquaponics is a new, fast emerging industry and an opportunity for investment.

Companies in Alberta, which are in a process of constructing or planning to build commercial aquaponics systems

- Nutraponics Canada Corporation, Sherwood Park
- Tollara Farms, Viking
- AFS Group, Ltd, Medicine Hat
- Broxburn Vegetables and Cafe, Lethbridge
- Current Prairie Fishermen Corp, Nobleford
-

Development of Hybrid Aquaponics/Poultry systems started at Crop Diversification Centre North in 2012

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Aerobic Bioreactor at CDC North

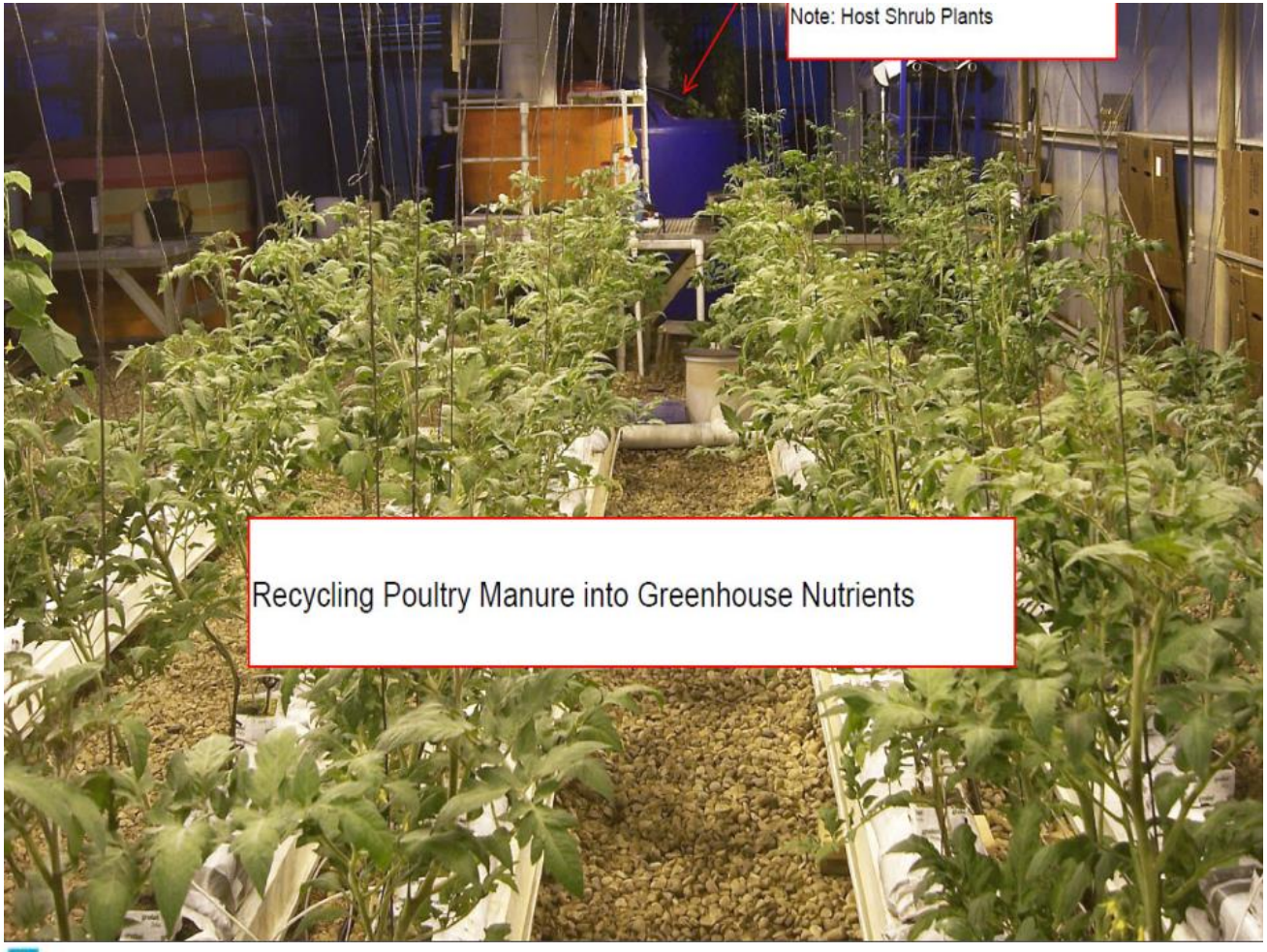

Poultry Manure 1000 L Bioreactor
the addition of ~ pure oxygen
makes this an **odorless** process!


Bioreactor ~1200 liters
- agitated and oxygenated
Probiotic Reservoir ~5000 liters
- oxygenated and water-cycled
- feed tank for substrate culture

- Nutrient-rich solution containing soluble organic and mineral components is produced as a result of aerobic biodigestion of poultry manure

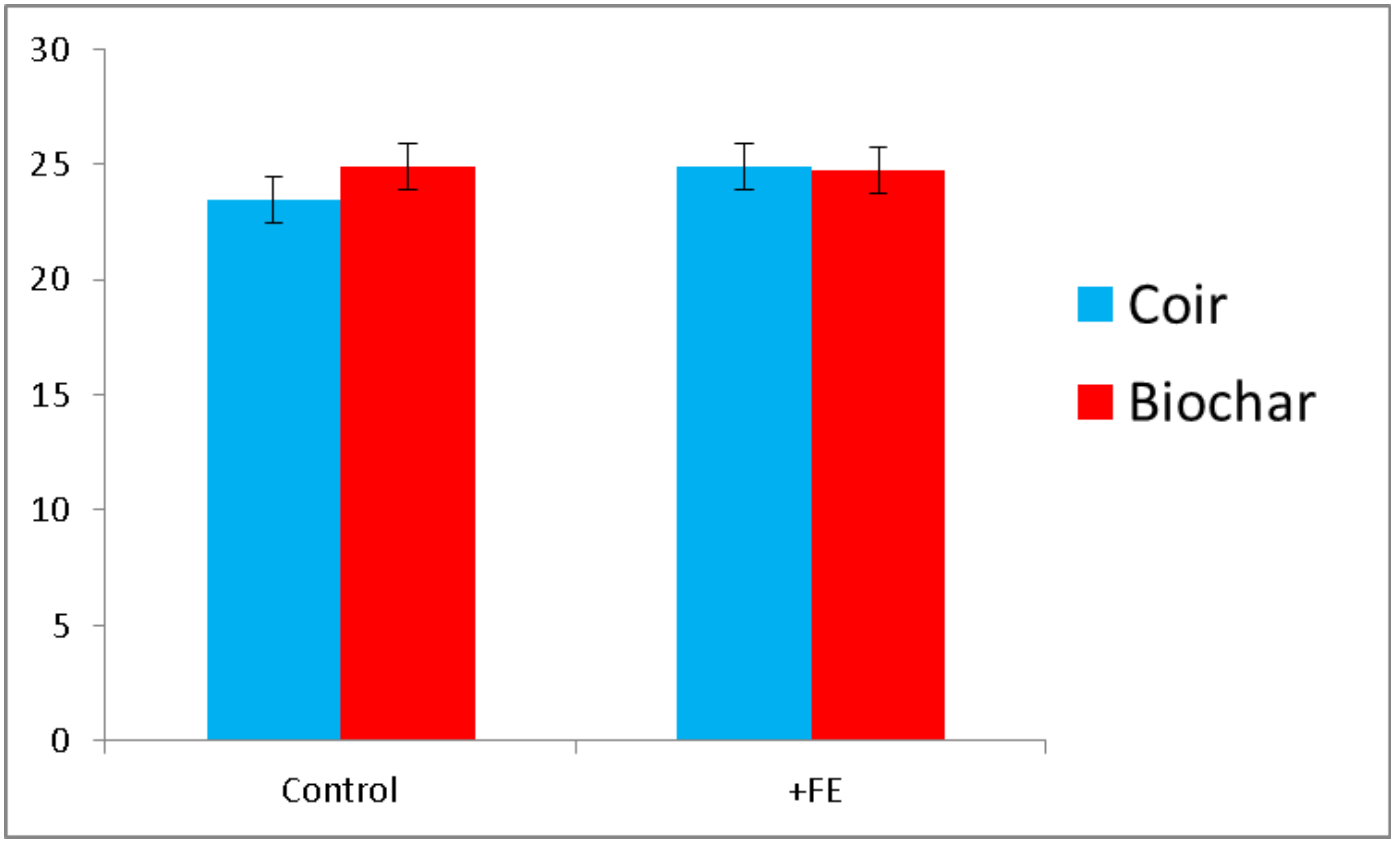
Only mineral component of poultry manure is left after the process including sand and oyster shells

Tomato plants 2 weeks after transplanting



Tomato plants 8 weeks after transplanting

Yield of tomato, cv. Torero, grown on poultry manure



Cucumbers grown on poultry digestate

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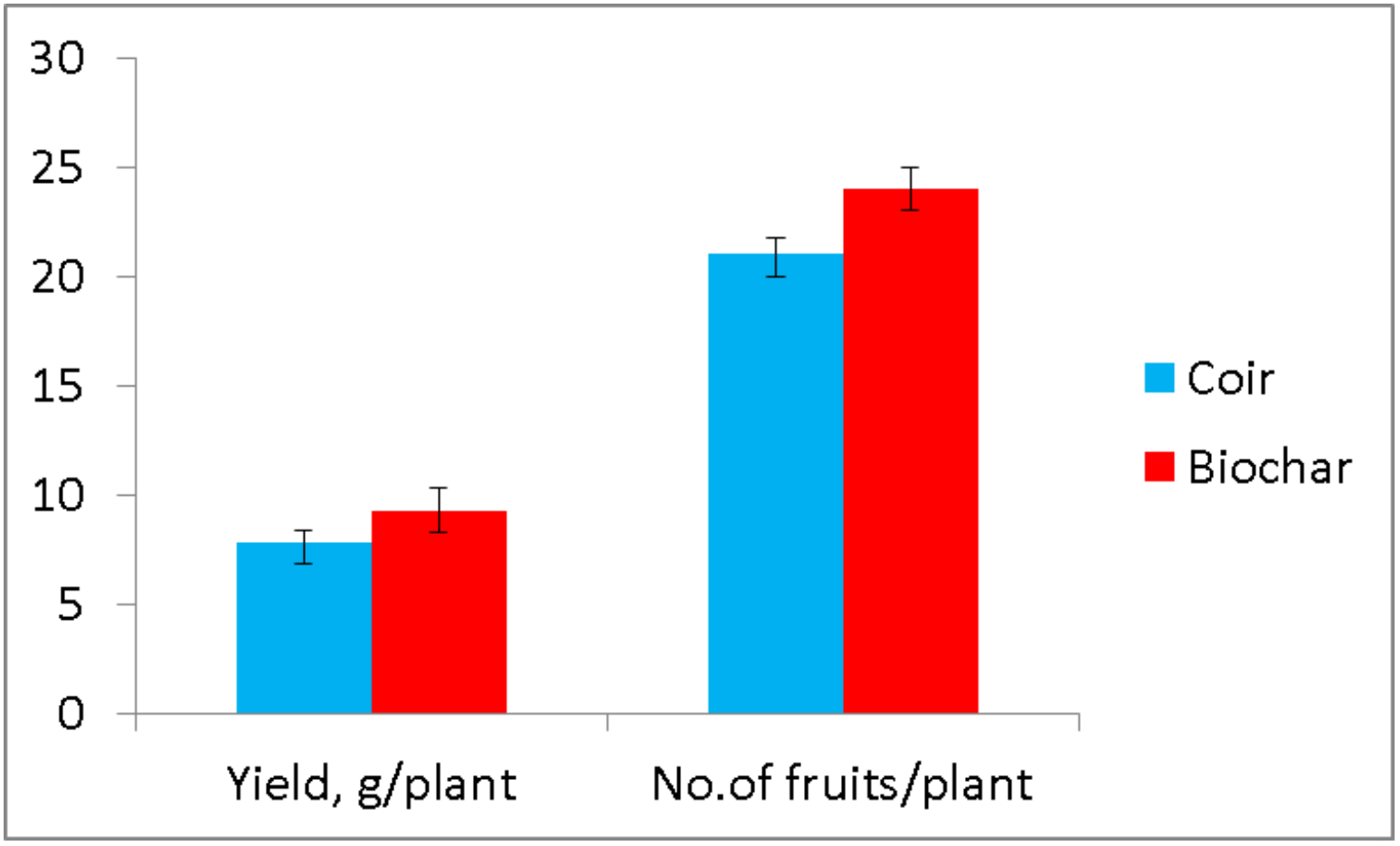
Yield of long English cucumber, cv Kasja, grown on poultry manure digestate



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Yield of pepper crop grown on poultry digestate

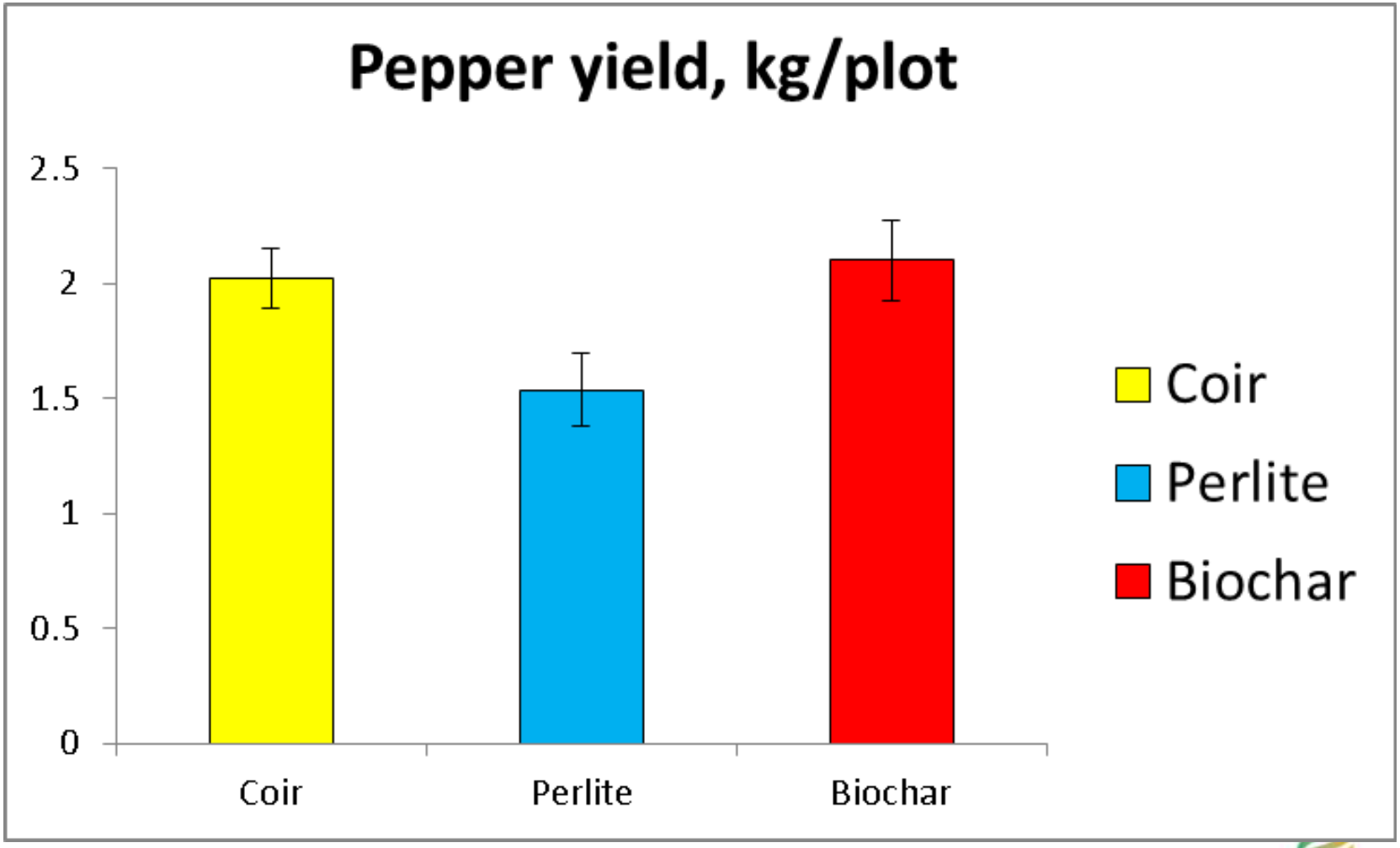

Fig tree production using mineralized poultry manure

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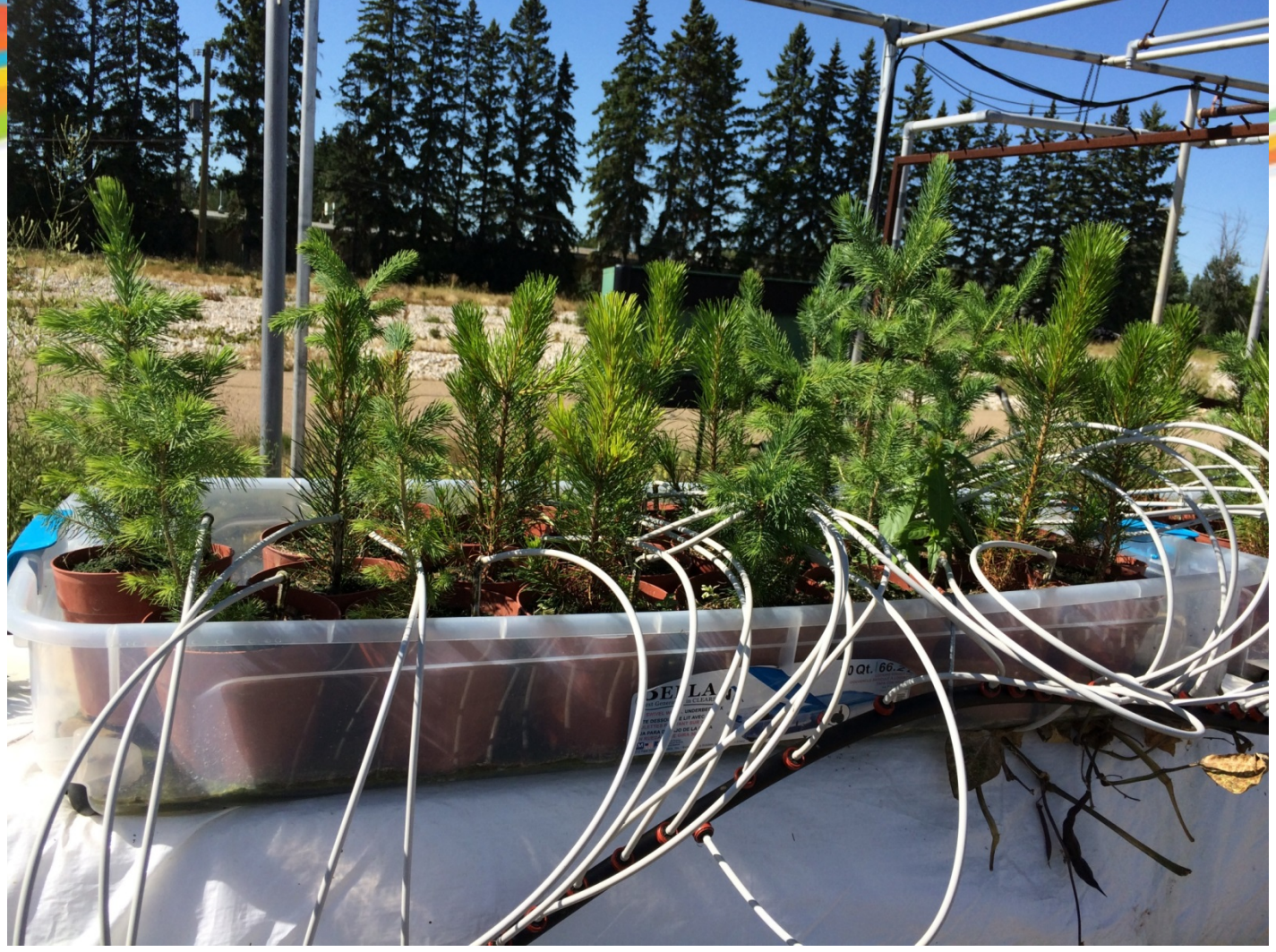
- Organically-rich sōlutions were trialed to grow tree seedlings in summer 2014.

- White spruce, *Picea glauca*, lodgepole pine, *Pinus contorta* var. *latifolia*, aspen, Populus tremuloides, and hybrid poplar were among tree species tested in the experiments.



Seedlings of lodgepole pine and white spruce grown on biologically active aerobic digestate. The seedlings were transferred in mid-July and doubled in height after two months.

Benefits of using biologically active nutrient solutions

- enhanced root biomass development
- strong seedlings establishment
- robust plant health and better resistance to root pathogens
- improved nutrient uptake, i.e. exceptional growth in low nutrient solutions
- enhanced plant sodium uptake (this allows for continual water recycling).

Use of Biochar as a soilless substrate in crop production

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- **Biochar is produced as a result of dry carbonization of organic material in anaerobic conditions, which starts at 200°-300° of torrefaction stage and completes at 450°C-550°C**

Slow Pyrolysis Experimental Set-up


15 05 2007

Horticultural biochar research started in Alberta in 2006

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Over 20 Biochar trials were conducted at Crop Diversification Centre in Brooks, Alberta, Canada, during six years of the study

Key objective of Biochar study in Alberta, Canada

Evaluate the performance of Biochar manufactured from several organic feedstocks as a soilless media for greenhouse crops grown in hydroponics and aquaponics including:

- **long English cucumbers,**
- **tomatoes**
- **Bell peppers**
- **basil**
- **ornamental crops**

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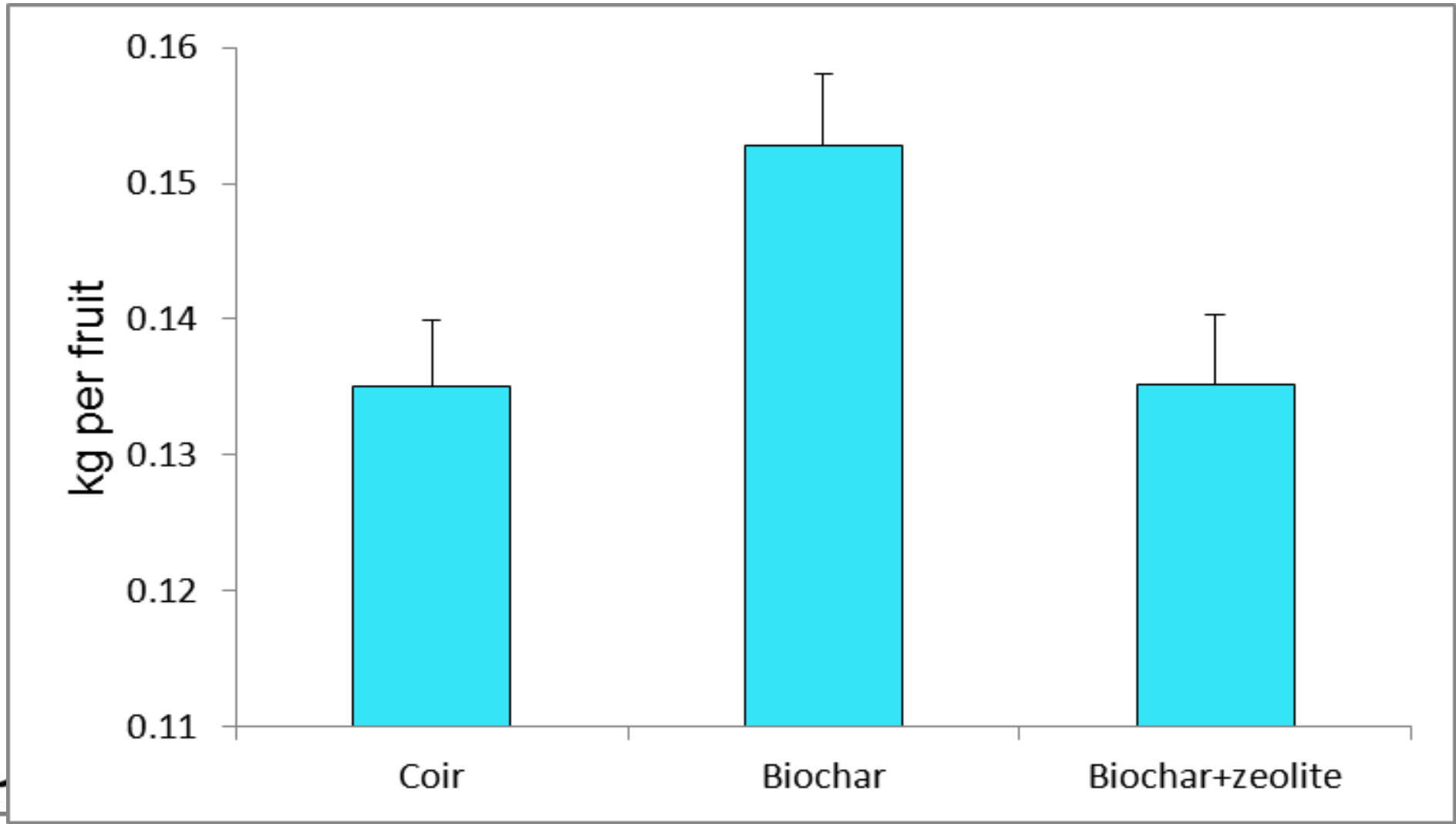
Long English cucumbers

Bell peppers

Tomatoes

Effect of substrates on weight of fruit in the 2nd experiment with cluster tomato, cv. Tradiro



Due to its very high resistance to bacterial degradation, biochar is an ideal substrate for aquaponics

- **Biochar is both plant substrate and a filtration medium, which makes aquaponics a great water polishing step for more demanding fish, such as salmonids**

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Advantages of greenhouse media based on carbonized organic material

- Higher stability
- Less bulk density
- Better physical characteristics, such as porosity and water retention capacity
- Wide distribution of pore size: meso-, micro- and nano-porosity

- **Ability to absorb phytotoxic compounds such as herbicides**
- **Buffering capacity**
- **Algicidal properties**
- **Suppression of root-born diseases is possible**
- **Free of pathogens and pests**

Production of biochar from diseased grain controls diseases and generates additional revenue for grain farmers


Biochar from diseased
(*Fusarium*-contaminated)
barley grain

Zero-waste approach may offer new marketing opportunities and improve economic sustainability of farms in Alberta

Our goals are environmental, but also economic sustainability of agriculture in Alberta.

Thank you for your attention!