The Science of Organic Agriculture

Andy Hammermeister - Managing Director
Nova Scotia Agricultural College
EcoFarm Day - Feb 2011

Outline

Organic Science Cluster

- About the OACC
- The science of organic
- Scientists working on organic agriculture
- Identifying research priorities
- The work of the Organic Science Cluster
- Organic Science Cluster 2
- Your research priorities

Organic Issues

- Natural vs organic
- Health and nutrition
- Genetic engineering
- Nanotechnology
- Feeding the world
- Others?

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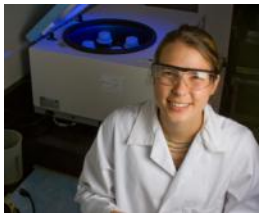
- Andy Hammermeister
- Ralph Martin
- Margaret Savard
- Joanna MacKenzie
- Karen Nelson
- Cheryl Paris
- Grad and summer students



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About the OACC

- OACC's Vision
  - Sustainable and science-based organic agricultural systems supporting healthy Canadian communities
- OACC's Mission
  - OACC facilitates research and education for organic producers and consumers to build sustainable communities

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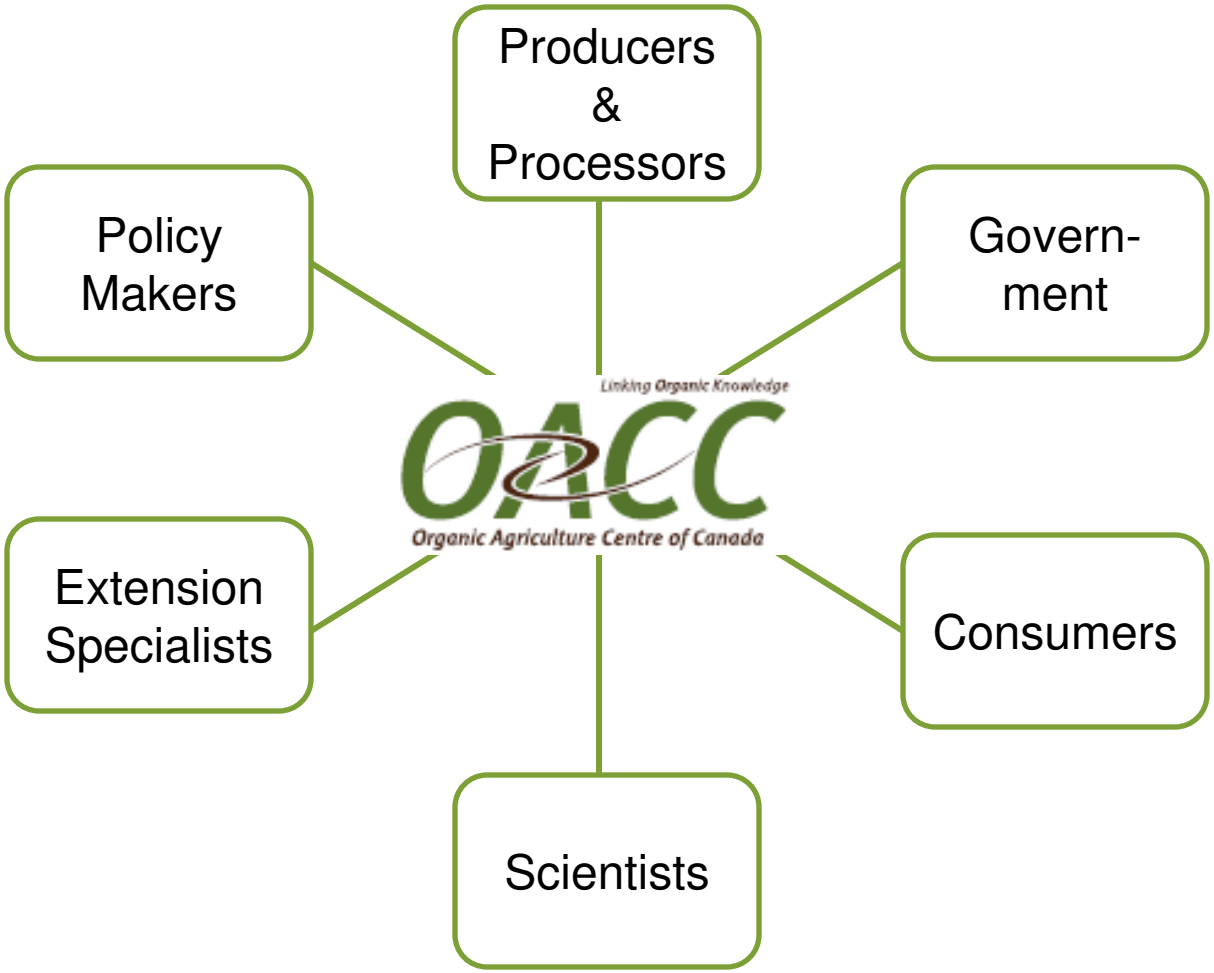

Scientific Integrity and Credibility

Principles of Organic Agriculture

(CAN/CGSB-32.310-2006)

- Protect the environment
- Maintain soil fertility
- Maintain biodiversity
- Recycle resources
- Livestock health & welfare
- Maintain product integrity & quality
- Local renewable resources

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The Science of Organic

The scientific method

- Clear question
- Controlled treatments
- Replicate
- Repeat

The scientists

- Need to ‘transition’ mentally
- Want to serve agriculture as a whole
- Interested in low-input and biological systems
- Most compete for funding
- Often need industry $ to leverage government $

Organic Research Needs Survey 2008 All Producers

(http://oacc.info/Docs/Canadian%20Organic%20Farmer%20Survey%202008.pdf)

1. Soil fertility and crop rotations
2. Consumer education
3. Soil quality
4. Rotations for specific problems
5. Ecology of crop rotations
6. Biology – improve soil life
7. Quality & nutrition of organic
8. Rotations and weed control
9. Pesticide reduction
10. Livestock parasites
11. Consumer education on organic standard
12. Biodiversity
13. Energy use
14. Buy local campaign
15. Quality & nutrition of organic field crops
16. Long term cropping systems research
17. Cultural disease controls
18. Livestock breeds
19. Cultural weed controls
20. Livestock feed

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Organic Science Cluster

- Applicant: Organic Federation of Canada
- Admin: OACC at NS Ag. College
- $6.5 mil AAFC, $2.2 mil industry + $0.1 mil provincial = $8.8 mil
- University and AAFC researchers
  - 84 Scientists involved
  - 53 researchers receiving funding
- 30 research activities in 9 research areas
- Communication plan

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Organic Science Cluster Funding Partners

Growing Forward | Cultivons l'avenir

Agriculture et Agroalimentaire Canada | Agriculture and Agri-Food Canada

CWB

Western Ag Innovations

Western Grains Research Foundation

novozymes Rethink Tomorrow

Prairie Oat Growers Association

Jardinerie Fortier

Les Serres Lefort

Demers fruits rouges, culture verte

Jardins-Nature

Sagami Saguenay • Sainte-Sophie

Les Fraises de l'Île d'Orléans

Berger Tourbières • Peat Moss

L'Abri Végétal Culture biologique en serre

Les Serres Frank Zyromski

Nature's Path

BC New Varieties Development Council

Anne's Pei Farm

Organic Meadow

Ontario Sheep

Home hardware

Homestead Organics

Organic Grocer

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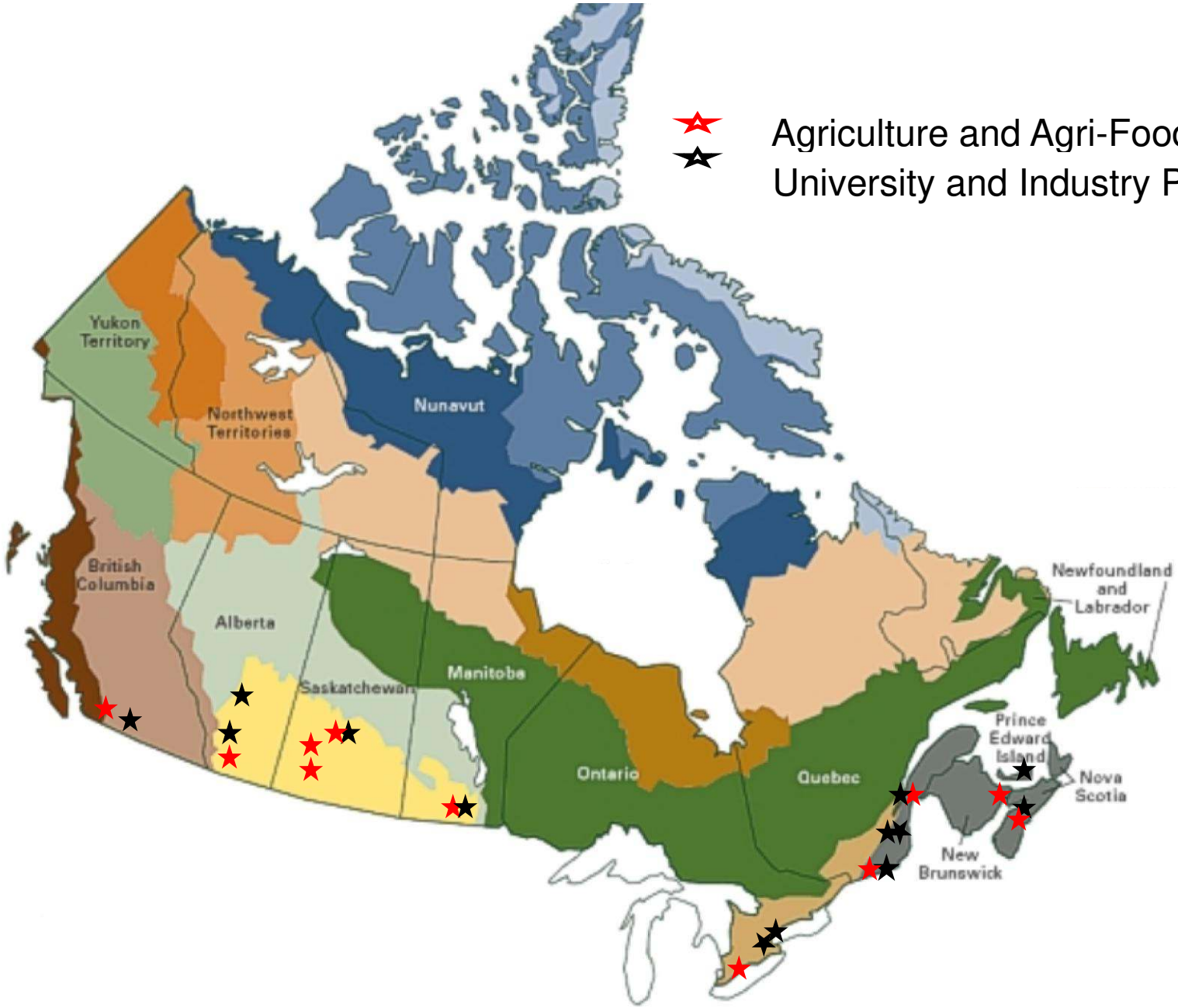
Organic Science Cluster Researcher & Activity Locations – 2009-2013



Organic Science Cluster: The Projects

A. Soil fertility
B. Grain-based systems
C. Greenhouse
D. Horticultural
E. Environmental
F. High-value fruits
G. Organic dairy
H. Food processing
I. Sheep parasites
J. Communication

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A. Biologically-Based Fertility Management

- Improve phosphorus and micronutrient uptake by managing soil biology
- 2 Research Activities Lead by:
- Dr. C. Hamel – AAFC
- Dr. D. Lynch - NSAC

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Peak Phosphorus

(Soil Association, 2010)

- P essential for life: energy transfer & genetic material
- P supply dependent on mining; may peak in 2033
- P shortages can reduce yield by 75%
- Shortages in P supply drove up prices 800% in 2007-08
- Conversion of P inputs into dietary P efficient in vegetables than meat
- Grass fed meat much more efficient meat

Peak Phosphorus: Benefits of Organic Management
(Soil Association, 2010)

- Managing nutrient loss;
- Using farmyard manure, crop residues and green waste composts as fertilizers;
- Increasing the availability of phosphorus to plants by encouraging microorganisms and mycorrhizal fungi;
- Using crops with high uptake efficiency

B. Integrated Grain-based Cropping Systems

- Tools and practices that:
  - Provide seed for organic
    - Dr. S. Fox – AAFC
  - Reduce soil disturbance
    - Dr. M. Entz – UofM
  - Build soil fertility
    - Dr. M. Entz – UofM
  - Support control of weeds.
    - Dr. S. Shirtliffe - UofS

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C. Organic Greenhouse Production
Production practices to extend seasons

- Crop nutrition
  - Dr. D. Ehret, AAFC
- Energy use efficiency and nutrient recycling
  - Dr. M. Dorais - AAFC
- Lighting & intercropping
  - Dr. S. Pepin, Laval
- Geothermal heat & tomato
  - Dr. D. Halleux, Laval
- Fertilization & irrigation in tomatoes
  - Dr. M. Dorais, AAFC
- Cuttings & potted plants
  - Dr. B. Dansereau, Laval

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D. Integrated Management of Horticultural Field Crops

- Pest and pathogen control
  - Dr. M. Leblanc - IRDA
- Nitrogen in rotations
  - Dr. J. Owen - AFFC
- Vegetable transplants
  - Dr. M. Dorais - AAFC
- Seedling peat blocks
  - Dr. N. Tremblay - AAFC
- Pumpkin
  - Dr. R. Nurse - AAFC

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E. Environmental Stewardship and Product Branding

Modeling:

- Farm scale energy and nutrient efficiency
  - Dr. D. Lynch - NSAC
- Global Warming Potential reductions by transitioning watersheds
  - Dr. R. MacRae – York U.

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Environmental

"Organic farming system attributes

(cropping, floral, and habitat diversity; nutrient intensity; soil management; and energy and pesticide use etc.)

are sufficiently distinct as to impart potentially important environmental benefits…". (Lynch, 2009)

Factors affecting yield & quality of potatoes

(Kunkel et al. 1972 (from Tisdale et al. 1985)

Can't be 'controlled'

- Day length
- Frost-free period
- Air temp., wind, humidity
- Light intensity
- Soil temperature

Grower – 'controlled'

- Moisture
- Insects
- Diseases
- Days grown
- **Fertilizers**
- Seed quality
- Seed piece size
- Number of plants
- Timely operations
- Variety
- Compaction

Total rotational energy consumption (MJ/ha) at the Glenlea long-term cropping systems study in Manitoba, 1992-2003. (Hoepner et al. 2005. Ren. Ag. and Food Systems)

Rotation	Inputs	Total Energy Consumption	Seed Energy	Fuel and Lube Energy	Machine. Energy	Pesticide Energy	Fertilizer Energy
WPWF	F+H+	68,498	7,902	16,133	2,367	7,116	34,980
WPWF	F-H-	24,233	7,902	14,229	2,102	0	0
WAAF	F+H+	49,255	3,657	18,184	2,515	3,499	21,400
WAAF	F-H-	22,181	3,657	16,213	2,311	0	0

F = fertilizer, **H** = herbicide, '**+**' = with, '**-**' = without
WPWF = wheat-pea-wheat-flax; **WAAF** = wheat-alfalfa-alfalfa-flax

See also: MacRae et al. 2010. **Improving Energy Efficiency and GHG Mitigation Potentials in Canadian Organic Farming Systems.** J. of Sustainable Agriculture 34: 549-580

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F. High-value fruit production

- Black currants
  - Dr. Hammermeister, OACC
- Weed management in blueberries
  - Dr. N. Boyd, NSAC
- Soil management in perennial fruits
  - Dr. L. Nelson, UBC
- Weed & disease management in apples
  - Dr. J. Reekie, AAFC
- Berries in high tunnels
  - Dr. S. Khanizadeh - AAFC
- Rosy Apple Aphid Control
  - L. Edwards

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G. Benchmarking the Organic Dairy Production System

Increase the profitability & competitiveness :

- Benchmarks for herd health & welfare
- Benchmarks for milk quality
  - Dr. T. DeVries, Guelph

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H. Food processing

- Replace or reduce nitrite/nitrate in organic cured meats.
  - Dr. J. Arul, Laval

I. Sheep parasite control

- Understand factors and interactions associated with over-wintering of larvae.
  - Dr. A. Peregrine, Guelph

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Where to next?

- Beginning to plan for the next Organic Science Cluster to start in 2013
- What are the research priorities that will have the biggest impact on the organic sector?

Organic-Natural-Conventional

	Organic	Natural	Conventional
Regulated standards (prescriptive management)	✓		
No synthetic pesticides	✓		
No synthetic fertilizers	✓		
No antibiotics	✓		
No GMO	✓		
No irradiation	✓	?	
No artificial preservatives	✓	✓	
No artificial flavours	✓	✓	
No artificial colours	✓	✓	

Antibiotics

- Antibiotics in hog manure found in runoff and leachate
  (Dolliver and Gupta. 2008. J. Environ. Qual. 37:*1227-1237)*
- Antibiotics found in manure can be taken up by plants
  (Dolliver et al. 2007 J. Environ. Qual. *36:1224-1230)*
- Composting can destroy many of the antibiotics
  (Storteboom et al 2007. J. Environ. Qual. *36:1695-1703)*
- *Some antibiotics can deteriorate without composting*
  (Dolliver et al. 2009. J. Environ. Qual. 37: 1245-1253)
- Resistance of soil bacteria to antibiotics can be higher in soils treated with manure containing antibiotics
  (Popowska et al. 2010. J. Environ. Qual. 39:*1679-1687)*

- Be careful of your source of manure, and compost if you believe it to be at risk

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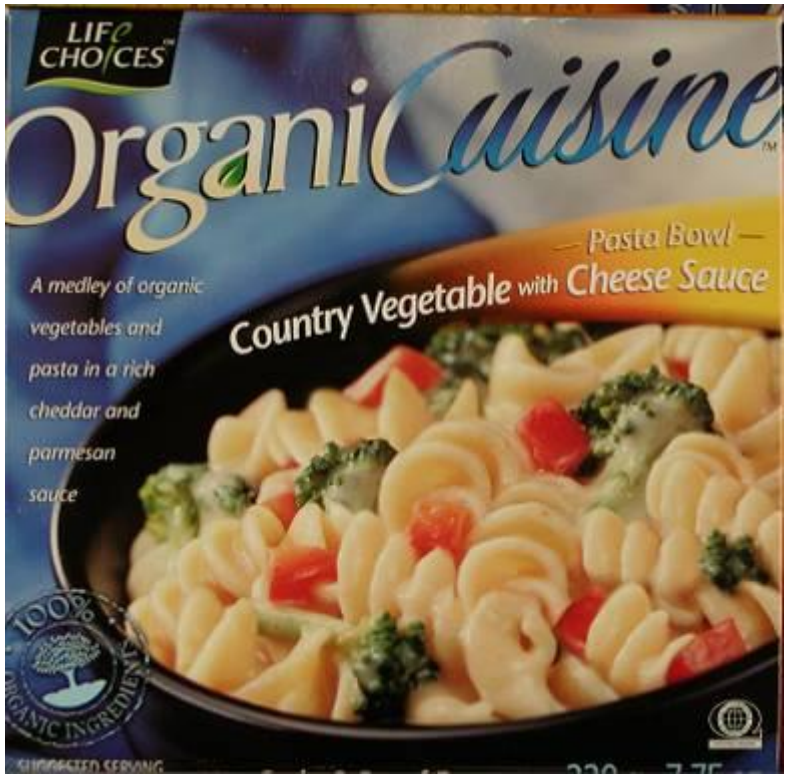
Food Additives

- > 500 additives permitted in non-organic processing, only ~30 permitted in organic
- Prohibitions: additives and ingredients <u>linked to:</u>
  - allergic reactions
  - headaches
  - asthma
  - growth retardation
  - hyperactivity
  - heart disease



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Pesticide Intake by Children

Lu et al. Environ Health Perspect. 116:537–542 (2008)

- Obj.: To determine the contribution of dietary intake to the overall OP pesticide exposure.
- "By **substituting organic** fresh fruits & veg. …, urinary metabolite concentrations **were reduced** to nondetected … levels for malathion and chlorpyrifos at the end of the **5-day organic diet** intervention period"

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Factors Affecting Phytochemicals in Fruits & Vegetables

- Crop type & cultivar
- Plant development
- Plant tissue, fruit size, stage of development, ripening
- Diseases & pests
- Pesticide application
- Soil conditions
- Fertilization
- Irrigation
- Season, location, climate
- Storage condition
- Processing conditions

Ref: Zhao et al. 2006. HortTechnol. 6:449-456

Need to measure and be able to explain differences. Many questions, hard to control & study whole systems.

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Health and Nutrition: Nutrients in food

- Organic plant products:
  - contain more dry matter and minerals (Fe, Mg);
  - contain more anti-oxidants such as phenols and salicylic acid
- Organic animal products contain more polyunsaturated fatty acids
- Organic vegetables contain far less nitrates, about 50% less;
- Organic cereals contain similar levels of mycotoxins as conventional
- Data on carbohydrate, protein and vitamin levels are insufficiently documented
- 94–100% of organic food does not contain any pesticide residues

Ref: Lairon. 2010. Agron Sus. Dev. 30: 33-41

Genetic Engineering

- Genetically engineered products prohibited in foods and production
- Precautionary approach
  - Allergens
  - Antibiotic resistance
  - Production of new toxins
  - Concentration of toxic metals
  - Resistance in pests
  - Unexpected genetic response

What is Nanotechnology?

- Research and technology development at the length scale of approximately 1 - 100 nanometer range.
- Creating and using structures, devices and systems that have novel properties and functions because of their small and/or intermediate size.
- A nanometer = one billionth of a meter.
- Human hair averages 20,000 – 80,000 nanometers in diameter. (One micron or micrometer = 1000 nanometers).
- Viruses tend to be about 100 nanometers in diameter.
- Bacteria are generally 1,000 to 10,000 nm. in diameter.

What is so exciting?

Reactivity

- When you reduce the size of the particles, the ratio of molecules on the outside of the particle as compared with those on the inside is greatly increased.
- The enormous surface to volume ratio greatly increases reactivity and changes mechanical, electrical and optical properties.

Nano threats to Organic

- Contamination of soil/biology/water
- Contamination of product/packaging
- Detect-ability
- Do thresholds need to be developed?
- Cost of keeping out of organic

Feeding The World
Population: 6.3 billion

Under-consumption

- > 2 bil malnourished
- = 30% of current production
- =100x current food aid
- = 2x amount of international ag. trade
- World food production must double by 2050 to support population growth

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Feeding The World

Ag. pop. 1.34 billion (Mazoyer 2005)

- 28 mil tractors (2%)
- 250 mil work animals (20%)
- 1 bil working with manual tools
  - 500 mil can't buy seed, fertilizers etc.
  - 200 mil have < 1 ha of land

Farmers responsible for:

- Land, inputs, equipment, labour
- Feeding their family

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Feeding the World

- Supply
  - Kind, amount, quality
  - Losses (harvest and post harvest)
  - Ecological limits
    - Land area
    - Soil quality
    - Climate
    - Pests & other risks
  - Labour
  - Tools/equipment
  - Inputs
- Distribution
  - Storage & handling
  - Transportation
  - Markets
  - Economics
  - Policy
  - Politics (stability)
  - Consumer acceptability

Can Organic Feed The World?

- The FAO Report (2007): shift to organic agriculture can produce enough food on a global per capita basis to feed the world's population over the next 50 years.
- Badgley et al (2007) Global review
  - "For most food categories, the average yield ratio (organic:non-organic) was slightly <1.0 for studies in the developed world and >1.0 for studies in the developing world."
  - "…organic methods could produce enough food on a global per capita basis to sustain the current human population, and potentially an even larger population, without increasing the agricultural land base."

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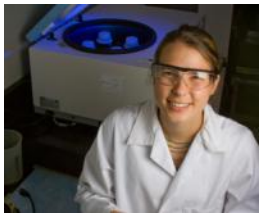

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