Organic Agriculture: Fundamentals in Practice

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What is Organic Agriculture?

- The production of crops and animals without the use of synthetic pesticides or fertilizers.

- “An organic farm, properly speaking, is not one that uses certain substances and avoids others; it is a farm whose structure is formed in imitation of the structure of a natural system.” - Wendell Berry
...To the maximum extent feasible, Organic Farming Systems rely on crop rotations, crop residues, animal manures, legumes, green manures, off-farm organic wastes, and aspects of biological pest control to maintain soil productivity and tilth, to supply plant nutrients, and to control insects, weeds and other pests. (USDA)
Fundamental Principles
from Stockdale et al, 2001 Advances in Agronomy 70

- Maintaining long-term soil fertility by maintaining SOM levels, fostering soil biological activity, and careful mechanical intervention
Nitrogen self-sufficiency through the use of legumes and biological N fixation, as well as effective recycling of organic materials, including crop residues and livestock wastes.

Supplementing crop nutrients, where necessary, by using nutrient sources which are made available to the plant indirectly by the action of soil microorganisms and chemical reactions in the soil.
Weed, disease and pest control relying primarily on crop rotations, natural predators, diversity, organic manuring, resistant varieties, and limited thermal, biological, and chemical interventions.
The extensive management of livestock, paying full regard to their evolutionary adaptations, behavioural needs, and animal welfare issues with respect to nutrition, housing, health, breeding, and rearing.
Careful attention to the impact of the farming system on the wider environment and the conservation of wildlife and natural habitats.
What’s science got to do with it?

(organic, integrated, and conventional apple production in WA)
Organic Management Improves Soil Quality

Mäder et al, 2002
Reganold et al, 1987 and 2001
Andrews et al, 2002
Bullock et al, 2002
Drinkwater et al, 1995
and more...

- VERY WELL DOCUMENTED
Soil Fertility and Biodiversity in Organic Farming

Mäder et al, 2002 (Science 296:1694)

- 21 year systems trial: Therwil, Switzerland
- Biodynamic/organic, conv, conv + FYM
- Winter wheat, potato, grass/clover rotation
- Yields: WW (90% of conv), potato (58-66% due to K fert and late blight), grass/clover (equiv)
- Nutrient input 34-51% lower in org
- Energy required to produce crop dry matter unit was 20-56% lower in organic
The soils were different...
Reduced tillage in organic systems

- Improved soil quality reduces soil erosion, so organically managed soils are less erodible, even though tilled

- There is a lot of interest in and work on organic reduced tillage around the world.
Enhance soil quality and biodiversity......

improve ecosystem function?

Impacts on plant diseases and insect pests
Effects of Organic Matter and Cover Crops on Soil Properties

BIOLOGICAL PROPERTIES:

disease suppression

- Shift the soil community to more desirable organisms with specific biological control activities
  - reduce pest incidence
Avocado root rot (*P. cinnamomi*) in avocado orchards

“Ashburner System” - continuous legume-maize cover crops, straw mulch, 4T/A poultry manure, pH maintained above 6

Suppression is biological (destroyed by heating), and is generated by pathogen suppression.

Suppression originates in mulch.

Malajczuk, 1983
Malajczuk, 1983
Phytophthora hyphae

Trichoderma

Phytophthora hyphae

Malajczuk, 1983
Phytophthora hyphae

Protozoa

Malajczuk, 1983
Competition for nutrients

- most fungal propagules require “signal” nutrients from the host to germinate and cause infection
- in the absence of these signals, the pathogen propagules won’t cause disease
- fungal pathogens also require nutrients to grow and infect
- a very large and active microbial community scavenges those nutrients, reducing disease severity.

Chen et al, 1987
Root rot of sweet corn
No mint waste

Mint waste
Microbial Activity and Disease Severity

Darby and Stone, unpub.

\[ y = -1.27x + 4.76 \]

\[ R^2 = 0.86 \]

Root rot rating (0-4)

Microbial activity

(µg hydrolyzed FDA min\(^{-1}\) g\(^{-1}\) dry wt)
Relationship between fPOM and severity of root rot of sweet corn.

Darby, 2003

$R^2 = 0.57$

Disease severity vs. fPOM (mg cm$^{-3}$)
Cover crops can:

- Increase disease
- Have no impact on disease
- Reduce disease
Dale Geis, Moses Lake WA
Wheat - white mustard - potato rotation
High yields
Improved infiltration and tilth
Easier potato digging
Reduction in wind erosion
Reduction in Verticillium wilt
WSU Mustard Field Day, October 2002

Biofumigation or soil building?
Field trial initiated August 2003 was in continuous corn for more than 10 years and has high root rot potential and few weed seeds.


Winters: mustard "Braco", mustard mix "Caliente", Saia oats, and an unamended control (4 treatments).

Field Trial 2
Winter/Summer Cover Crops Trial: 2003-04
European corn borer ovoposition in organic and conventional field crop systems

Phelan et al 1995

- Three farm pairs in Ohio (over 25 yr organic - red clover, corn, soy, wheat; soy/corn conventional)
- Soils brought into greenhouse and planted to corn
- Amended with ammonium nitrate or compost
- Adults released into greenhouse and eggs counted on plants.
- Ovoposition consistently low in organically grown soils and highly variable in conventional soils
- Ovoposition negatively related to plant tissue protein content
- A quadratic model of Zn, N, and Al plant tissue contents strongly related to ovoposition

nutrient balance has also been implicated in plant disease interactions, although very little work has been done
Fundamental differences between conventional and organic tomato agroecosystems in CA

- Drinkwater et al, 1995 (soils, overview)
- Workneh et al, 1994 (plant pathology)
- Letourneau and Goldstein, 2001 (entomology)
- 9 org and 9 conv tomato farms
- Sacramento Valley, CA
Reduced soilborne disease incidence

Corky root damage (log%)

Drinkwater et al, 1995
Factors related to disease incidence

Slightly increased total organic C on organic farms

FDA activity much higher on organic farms (indicator of active organic matter)

Drinkwater et al, 1995
Foliar thrip damage
Foliar flea beetle damage
Foliar caterpillar damage
Foliar leaf miner damage
Fruit puncture

Overall, no difference in tomato damage

Letourneau and Goldstein, 2001
Western flower thrips

Leafhoppers

Green peach aphid

Bean aphid

Flea beetles

Nor, overall, in pest abundance....
Spined stilt bug

Minute pirate bugs

Omnivorous plant bugs

Common crab spider

Parasitic Hymenopterans

However, natural enemy abundance was greater on organic farms.

Letourneau and Goldstein, 2001
Factors related to relative abundance of arthropod species

- Bare vs. vegetative winter fallow
- Insecticide use intensity
- Relative amount of surrounding natural vegetation
- Conventional vs. organic management in general
- Greater or less than 25% natural lands within 1 km

Letourneau and Goldstein, 2001
Herd Health (Hardeng and Edge, 2001)

- Norwegian Dairy Herd Recording data sets
- Matched three conv: one org herd
  (based on size and region: 31 org, 93 conv)
- Org herds typified by lower intensity production and lower use of concentrates, more varied feedstocks, longer spring calving, older cows, access to the outdoors, more complex breeding composition

Organic : conventional odds ratios

- Mastitis, ketosis and milk fever incidence were all lower on organic farms
- Low disease incidence in organic herds has been reported previously (e.g. Weller and Bowling, 2000)
Ecological agriculture is constantly evolving

“The best way to farm hasn’t been invented. I reserve the right to change my mind tomorrow.”

-- Dick Thompson, Boone, Iowa farmer