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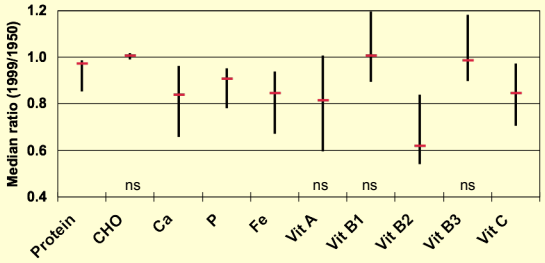
Outline

- dilution of minerals, vitamins & phytonutrients in crops
- biologically intensive soil-fertility management
  - enhanced phytochemicals & amino acids in apples & tomatoes
  - offset dilution effect in tomatoes
  - enhanced gene expression
  - delayed senescence & disease inhibition
- integrated hypothesis for crop improvement
  - C:N cycling & stress defenses (i.e. growth-differentiation balance hypothesis)

Declining nutrient composition

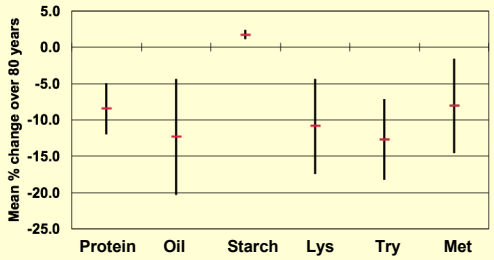
Historical USDA data for 43 garden crops (1999 vs. 1950)



Davis, *HortScience* 44:15, 2009

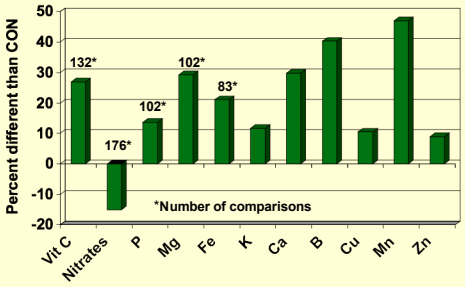
Genetic dilution

Side-by-side data of 45 maize cultivars (1920 to 2001)



Davis, *HortScience* 44:15, 2009 (calculated from data of Scott et al., 2006)

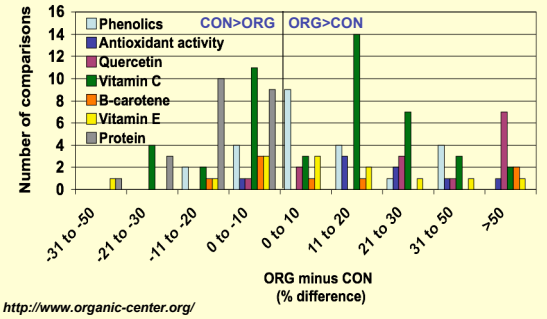
Organic fertility management



Worthington, *J. Alternative & Complementary Medicine* 7:161, 2001

Differences in nutrient content

236 valid organic-conventional comparisons (1980-2007)



http://www.organic-center.org/

Sampling variables

- site characteristics
  - topography, air, water, soil, climate, weather
- history
- year/season
- genetic cultivar
- pest & pathogen pressure
- handling, storage & processing
- farming practices
  - e.g. fertility management

Sustainability of three apple production systems

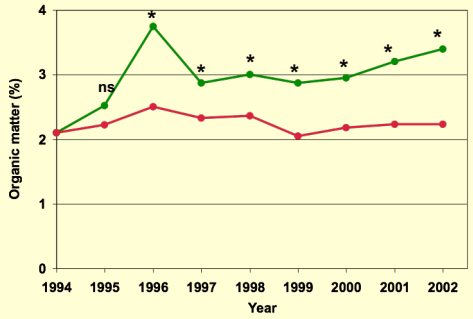
Reganold, Glover, Andrews & Hinman
Nature 410: 926, 2001

- Crop quality
- Soil quality
- Farm profitability
- Environmental risks of agrochemicals
- Energy efficiency

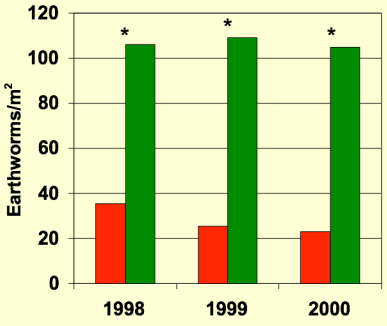
Apple orchard productivity and fruit quality under organic, conventional, and integrated management

Peck et al., *HortScience* 41:99, 2006

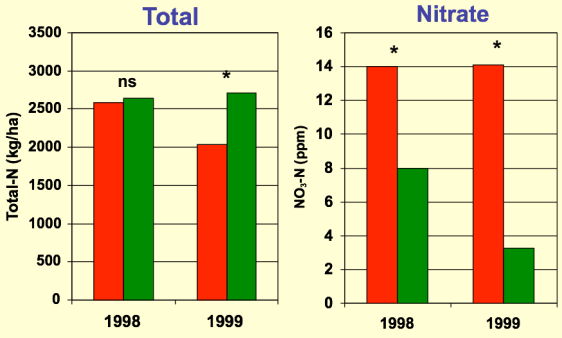
Soil organic matter



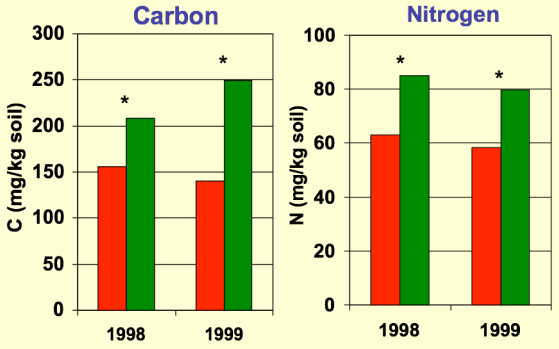
Earthworms



Soil nitrogen

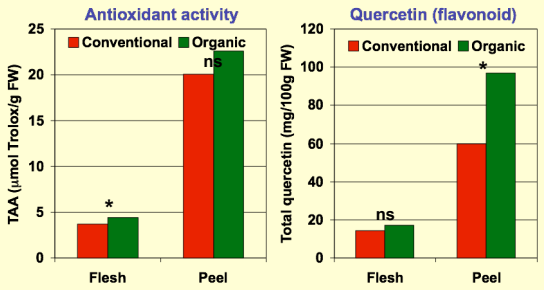


Microbial biomass



Fruit phytochemicals

Gala apples



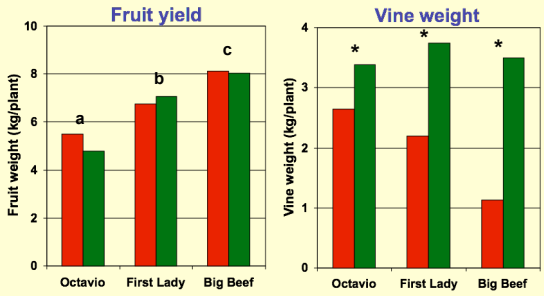
Phytochemical dilution

Tomato experiment

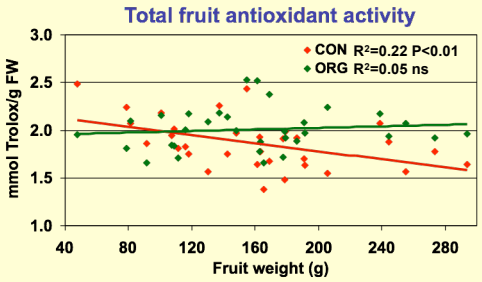
- small, medium & large-fruited hybrids
- soluble/chelated salts or organic fertilizers
- same total N applied

Yield and plant growth

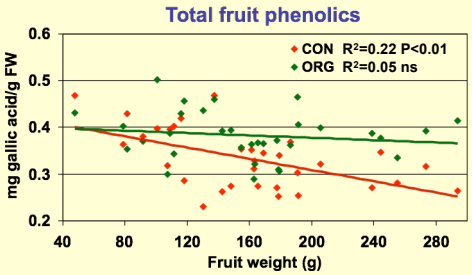
Tomatoes



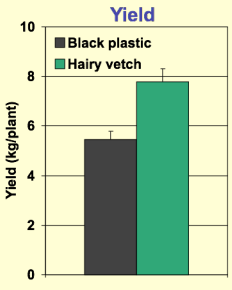
Dilution of antioxidant activity
'First Lady' tomato



Dilution of phenolics
'First Lady' tomato

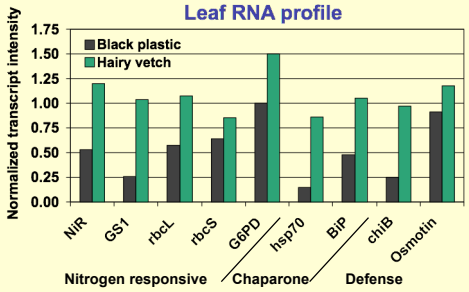


Tomato mulch studies



Neelam et al.,
J. Expt. Bot. 59:2337, 2008

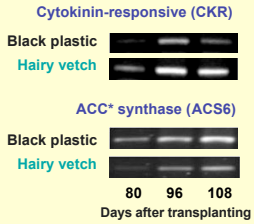
Gene expression in tomato



Kumar et al., *Proc. Natl. Acad. Sci.* 101:10535, 2004

Phytohormone genes in tomato

Leaf RNA profile

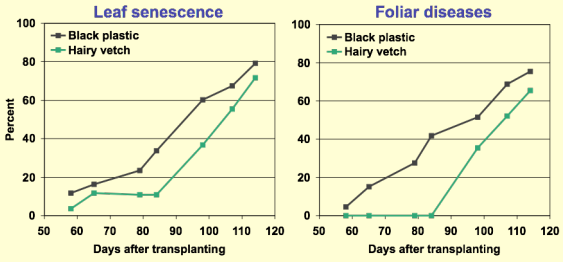


- cytokinin (CK) signal delays senescence
  - chitinase & osmotin delay feedback inhibition by CK
  - maintain continual CK signal from root to leaf
- ACC synthase catalyzes ethylene (C_2H_4)
  - C_2H_4 promotes senescence

*1-aminocyclopropane-1-carboxylate

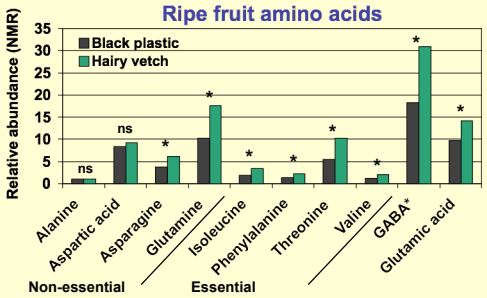
Kumar et al., *PNAS* 101:10535, 2004

Reduced senescence & disease



Kumar et al., *PNAS* 101:10535, 2004

Amino acids in tomato



*Gamma-AminoButyric Acid

Neelam et al., *J. Expt. Bot.* 59:2337, 2008

Other fruit genetic & metabolic responses

- increased gene expression of S-adenosyl-methionine (SAM) decarboxylase in HV
  - increased polyamines (cell growth) related to amino acid accumulation in fruit
- increased gene expression PEP carboxylase (CO_2 assimilation) & isocitrate dehydrogenase (NADH production) in HV
  - maintain N:C balance in leaves & roots

Neelam et al., *J Expt Bot* 59:2337, 2008