Antibiotic Use in Organic vs. Conventional Disease Management

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The Ohio State University

- Public land grant university in Columbus, OH
  - Founded in 1870
  - More than 50,000 students

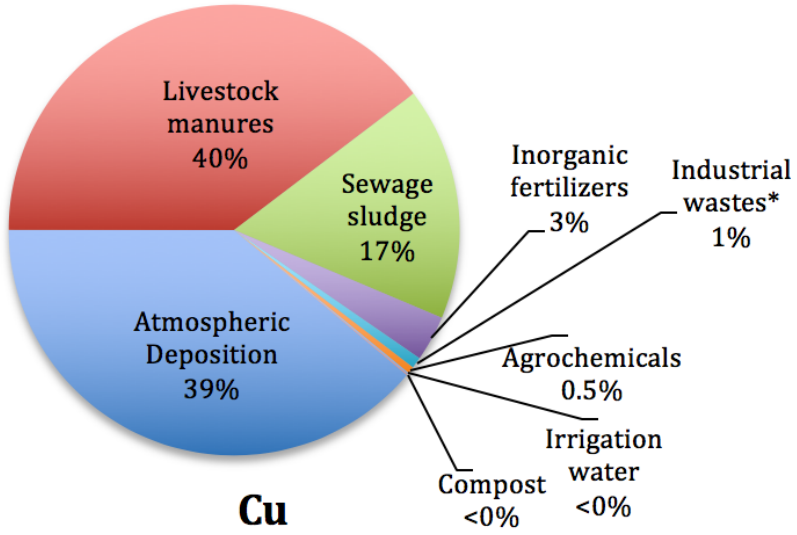
- College of Food, Agricultural and Environmental Sciences
  - Teaching, research and extension in agriculture and the environment

Antibiotic Use in Horticulture

- Summary: Dr. George Sundin
  PACCARB Public Meeting #9 May 2018
  - <0.5% total antibiotic use in U.S.
    - Streptomycin – used since the 1950s
    - Oxytetracycline – used since the 1980s
    - Kasugamycin – used since 2015 (only plant agriculture)
  - Copper
    - More widespread use in crop agriculture than antibiotics
    - Potential co-selection of resistance to metals and antibiotics

Copper Use in Agriculture

- Used in crop agriculture since the 18th century
  - Broad spectrum, contact pesticide
  - 19th century – copper sulfate + lime – Bordeaux mixture
- Multiple formulations
  - Fixed copper: -hydroxide, -oxide, -oxychloride
  - Copper sulfate
  - Reduced rates
  - Reduced phytotoxicity



Nicholson et al. 2003
Data for England & Wales

Copper Use in Plant Protection

- Used widely for **fungal** and **bacterial** diseases affecting:
  - Perennial fruit crops
    - Grapes, tree fruits, nuts
  - Vegetable crops, herbs
  - Perfume, aromatic & medicinal plants
  - Ornamentals
  - Seed production crops
  - Potato late blight
  - Seed-transmitted fungal diseases of wheat and rye

  - Conventional
  - Organic
  - Home gardens

NASS 2017

Table 3. Top fungicides by percent of planted acres, Selected Vegetables, 2016 Crop Year

Vegetable	Fungicide	% of planted acres	Avg. Rate for Year (lbs/acre)	Total applied (lbs)
Bell Peppers	Copper hydroxide	50	1.818	38,100
	Mancozeb	36	2.914	42,300
	Azoxystrobin	36	0.237	3,500
Onions	Mancozeb	57	3.276	219,000
	Copper hydroxide	46	0.903	45,700
	Chlorothalonil	44	3.080	147,000
Pumpkins	Chlorothalonil	59	4.438	105,600
	Copper hydroxide	34	0.893	12,100
	Azoxystrobin	25	0.226	2,300
Squash	Chlorothalonil	65	3.550	74,300
	Copper hydroxide	26	1.466	12,200
	Sulfur	17	10.219	56,100
Watermelons	Mancozeb	56	3.046	176,700
	Chlorothalonil	55	4.257	244,300
	Copper hydroxide	48	0.534	26,700

Conventional Disease Management

- Disease-resistant varieties, including GMOs
- Cultural practices
  - Crop rotation, sanitation, site selection, clean seeds, soil improvement, vector control, water management
- Biopesticides
  - Biologicals, botanicals
- Fungicides, bactericides, nematicides
  - 2014 global fungicide market > $11B
  - Current global market value copper-based fungicides = $970 million
  - Resistance to fungicides and bactericides is common among plant pathogens

Organic Plant Disease Management

- **Permitted** tactics
  - Disease-resistant varieties, rootstocks
  - Cultural practices
    - Similar to conventional but emphasized
  - Biopesticides
    - Biologicals, botanicals
- **Restricted** tactics
  - Sulfur-based pesticides
  - Copper-based pesticides
- **Prohibited** tactics
  - Synthetic fungicides/pesticides
  - GMOs

Copper Use in Organic Horticulture

- Grape downy mildew
  - Most varieties susceptible
  - Rates can reach 80 kg/HA
  - ~15 applications/season
- Other big users:
  - Apple scab
    - Popular varieties all susceptible
    - 10-20 applications/season
  - Potato and tomato late blight
    - 10-20 applications/season

Downy mildew (photo by M.L. Lewis Ivey)

Provost & Pedneault 2016 Scientia Hort.

Limitations to Copper Use in Crops

- Copper is phytotoxic at low pH
- No systemic activity; contact only
  - Is not effective once a pathogen infects a plant
- Soluble in water
  - Frequent re-applications; toxic buildup in soil
- Resistance is common in bacterial plant pathogens and in some fungi/oomycetes
- Much better, safer (modern) fungicides are available for conventional crops

Why Use Copper for Plant Protection?

- Better bactericides not available for most crops
  - Antibiotic use is highly restricted
- Copper-based products better than "alternatives" for organic crops
- Copper –based products are relatively inexpensive

Treatment	% Foliar disease
Control – water run off	66.0 ab
Humega	75.9 a
Timor	67.6 ab
StorOx	61.4 ab
Biodynamic 508 – equisetum arvense	59.0 ab
Kaligreen	47.9 abc
Sonata + Champion WP	45.6 abc
Serenade	44.3 abc
Timorex	44.1 abc
Trilogy	39.5 bcd
Garlic Barrier	39.4 bcd
SW-3	37.1 bcd
Sonata	37.0 bcd
StorOx alt with Champion WP	25.0 cde
Serenade + Champion WP	21.4 cde
Champion WP	10.8 de
Bordeaux mixture	5.0 e

Can Copper Use be Reduced?

- EU drastically limited copper use
  - limit of 6 kg/HA/season in organic grapes

- US (2017): “The NOSB review of this material acknowledges that copper is both harmful in the environment when misused and absolutely necessary to grow many crops to protect against disease.”
  - No additional restrictions recommended

Options to Reduce Copper Use

- Breed varieties with multiple disease resistance
  - Traditional breeding is slow, GMOs not acceptable
    - New gene editing technology may be more palatable
- Better tactics for bacterial disease management
- More effective natural competitors
  - Microbiomes may be source of effective disease suppressive products and systems
- Greater implementation of protected (covered) culture
  - Protect high value crops from the elements, many but not all diseases

Summary

- Use of antibiotics also used in humans and animals is minor in crops
- Both conventional and organic farmers use pesticides
  - Copper- and sulfur-based products are used most in organic systems
  - Copper-based products are the main bactericides in both
- The EU has restricted copper use in organics; the US has not to date
- Use of all pesticides, including copper, may be reduced by advances in plant breeding, microbiome analytics and protected culture systems

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AND ENVIRONMENTAL SCIENCES

Thank you