

Antimicrobial class	Subclass	Agents (some examples)
Carbanilides		Nicarbazin
Glycolipids		Bambermycins
Glycophospholipids		Flavophospholipol
Ionophores		Laidlomycin
		Narasin
		Lasalocid
		Salinomycin
		Maduramicin
		Salinomycin
		Monensin
		Semduramicin
Oligosaccharides		Avilamycin
Pleuromutilins		Tiamulin
Quinoxalines		Carbadox
Triazines		Toltrazuril
Others		Robenidine
Fungicides used for plant protection^c		
Azoles		Azaconazole
		Hexaconazole
		Bitertanol
		Hymexazol
		Bromuconazole
		Imazalil
		Cyproconazole
		Metconazole
		Diclobutrazol
		Myclobutanil
		Difenoconazole
		Penconazole
		Diniconazole
		Prochloraz
		Epoxiconazole
		Propiconazole
		Etridiazole
		Tebuconazole
		Fenbuconazole
		Tebuconazole
		Fenchlorazole
		Triadimefon
		Fluquinconazole
		Triadimenol
		Fluquinconazole
		Triazoxide
		Flusilazole
		Tricyclazole
		Flutriafol
		Triflumizole

^aRegistration, or evidence of use, between 2000 and 2013.

^bThese antibacterial classes and/or subclasses of antibiotics are classified as “critically important” for human health by WHO.

^cFungicides used for plant protection in EU 2000.

is integrated and animal and human fecal waste is added to fish ponds. In this “soup,” resistant bacteria from humans and animals are mixed with environmental bacteria and potentially multiple antibiotics contained in fish feed. As an example, aquaculture likely facilitated genetic transfers in multiresistant *Salmonella Kentucky* (Le Hello *et al.*, 2011; Collignon, 2013).

ANTIMICROBIAL USE IN HORTICULTURE, INCLUDING FRUIT AND VEGETABLE PRODUCTION

There are minimal data regarding the quantity and type of antibiotics used in horticulture, but usage occurs (McManus *et al.*, 2002; Stockwell and Duffy, 2012; Gusberti *et al.*, 2015; Aćimović *et al.*, 2015; Mayerhofer *et al.*, 2009; Fruit Growers News, 2007; Traub and Leonhard, 1995; Senkel *et al.*, 2003; Goodman and Johnston, 1957–59). One example is the use of aminoglycoside sprays (gentamicin and streptomycin) on apples and pears to control fire blight, with streptomycin

residues detected on apples up to 86 days after the last application of the spray (Mayerhofer *et al.*, 2009). Because aminoglycosides are generally heat stable, they are likely to persist on (or in) these fruits despite cooking (Traub and Leonhard, 1995).

In addition to antibiotics, antifungal agents such as azoles, are now used in large quantities in agriculture for crop protection and material preservation (Hof, 2001; Verweij *et al.*, 2009; Mortensen *et al.*, 2010; Chowdhary *et al.*, 2013; Parker *et al.*, 2014; Bromley *et al.*, 2014; Bowyer and Denning, 2014; US Forest Service, 2016; U.S. EPA, 2006; ECDC, 2013; Eurostat, 2001; ECPA, 2012; see Table 2.1). In Europe in 1996, over 9,000 tons of azoles were used as plant and crop protection. In the UK in 2008, 165 tons of triazole antifungals were used on wheat; while large volumes of triazole are used on beans and oilseed rape. Triazoles were also used on dessert apples, field roses, hops, and strawberries (US EPA, 2006; ECDC, 2013; Eurostat, 2001).

Triazoles (difenoconazole, tebuconazole, and propiconazole) are used for the control of fungal diseases on lawns