Table S1. Current plant protection situation for selected crops with high importance in European countries. The table shows important diseases, available alternative plant protection products (PPP), and expert assessment on the effective use of these alternative plant protection products.

Crop	**EPPO code[a], English name, scientific name**	**Alternative PPP in use**	**Comments**
Olives	CYCLOL leaf spot of olive *Venturia oleagina* CERCCL violet spot of olive *Pseudocercospora cladosporioides* CAPDEL sooty mould of olive *Capnodium elaeophilum* GLOMCI anthracnose of olive *Glomerella cingulata* ALTETE Black rot of olive *Alternaria tenuissima* FOMESP Fomes fomentarius STERSP wood canker *Stereum spp*. (wound treatment with copper) POLPSP wood canker *Polyporus sp.* (wound treatment with copper) PSDMSA bacterial canker of olive *Pseudomonas savastanoi pv. Savastanoi*	Propolis; Beeswax; Microorganisms; Bicarbonate; Equisetum; Sulphur; Polysulfide; Garlic	Very high dependency on copper use; alternatives (Potassium bicarbonate plus pinolene, *Bacillus subtilis*) not widely used. No stand-alone alternative available.
Grapes	PLASVI downy mildew of grape *Plasmopara viticola* GUIGBI black rot *Guignardia bidwellii* XANTAM bacterial blight of grapevine *Xylophilus ampelinus* BOTRCI grey mould *Botryotinia fuckeliana* PHYP64 grapevine flavescence dorée phytoplasma *Phytoplasma vitis* PSPZTR red fire disease of grapevine *Pseudopeziza tracheiphila* EUTYLA dieback of grapevine *Eutypa lata* UNCINE powdery mildew of grapevine *Erysiphe necator* PSPZTR red fire disease of grapevine *Pseudopeziza tracheiphila*	Laminarin; Sulphur; Potassium bicarbonate; Myco Sin (Equisetum arvense + Aluminium Sulfate)*;* COS OGA (Chitosan + Pectin depolymerizations); *Oleum foeniculi;* Sweet orange essential oil (prev-am)*;* Sodium bicarbonate; *Aureobasidium pullulans* (DSM 14940 & DSM 14941); *Bacillus amyloliquefaciens subsp. plantarum* (D747)*; Bacillus subtilis* (QST 713) ; Potassium bicarbonate; Vinegar; Biodynamic	Downy mildew is by far the most important disease necessitating copper use. Alternatives are not widely used due to limited efficacy and/or costs. Aluminium sulfate has reported efficacy against downy mildew and other grapevine diseases albeit not at same level as copper. COS OGA and laminarin (inducers of resistance) have limited activity. No stand-alone alternative is available. Copper reduction strategies fully implemented in countries with traditional low copper use permission (3-4 kg ha^{-1}).

		preparation; Sulphur; Microrganisms; Equisetum Polysufide; Garlic	Against powdery mildew, copper alternatives (Sulphur, *Oleum foeniculi*, potassium bicarbonate) are widely used.
Almonds	STIGCA shot hole *Stigmina carpophila* MONIG brown rot *Monilinia sp* TRANPS stone fruit rust *Tranzschelia discolor* CYTOG Leucostoma canker *Leucostona cincta* FUSCAM almond canker *Diaporthe amygdali* VENTCA scab of almond *Venturia carpophila*	Sulphur; Microorganisms; Potassium Bicarbonate; Equisetum; Polysulfide; Garlic	Limited information available. Alternatives not widely used; reduction potential probably not exploited.
Hazelnuts	XANTCY bacterial blight *Xanthomonas arboricola* PSDMSX bacterial canker *Pseudomonas syringae* AGRBTU *Agrobacterium tumefaciens* Anthracnose *Piggotia coryli* CYTOCO Cytospora canker *Cytospora corylicola* 1ARMLG Armillaria Root Rot *Armillaria spp*. CRSPAN Eastern Filbert Blight *Anisogramma anomala* Kernel Molds: RAMUEN *Ramularia endophylla,* RAMUSP Ramularia sp., PHOPSP *Phomopsis sp.,* *Septoria ostryae* Hazelnut (Corylus avellana)-Leaf Spots Hazelnut (Corylus avellana)-Powdery Mildew Hazelnut (Corylus avellana)-Sooty Mold Hazelnut (Corylus avellana)-Wood Decay Hazelnut (Corylus avellana)-Brown Stain Hazelnut (Corylus avellana)-Catkin Blast	none	Hazelnut has a wide range of bacterial diseases, control therefore heavily depends on copper. Limited information available. Alternatives are presumably not used; reduction potential probably not exploited
Walnuts	XANTJU bacterial blight of walnut *Xanthomonas arboricola pv. Juglandis* GNOMLE anthracnose of walnut *Ophiognomonia leptostyla*	Sodium bicarbonate	Walnuts have a range of bacterial diseases. Therefore, control heavily depends on copper.
Apples	VENTIN apple scab *Venturia inaequalis* PODOLE powdery mildew of apple *Podosphaera leucotricha* NECTGA European canker of apple *Nectria galligena*	Sulphur; NaHCO3; Lime sulphur; Potassium bicarbonate; *Bacillus subtilis* (QST 713); Laminarin;	Copper reduction potential based on available alternatives is fully exploited in most countries; no adequate solutions

	ERWIAM fireblight *Erwinia amylovora* BOTSOB black canker of apple *Botryosphaeria obtusa* DIAPER bark canker of pome fruit *Diaporthe eres* CYTOSP *Cytospora sp.* BOTRCI botrytis *Botryotinia fuckeliana* PEZIAL bitter rot of apple PENIEX blue mould of apple *Penicillium expansum* MONIFG brown rot *Monilinia fructigena* PHYTCC collar rot of apple *Phytophthora cactorum* VALSMC *Valsa malicola* PENIEX blue mould of apple *Penicillium expansum* MYCOPO black spot of apple *Mycosphaerella pomi*	Aluminium Sodium bicarbonate; *Aureobasidium pullulans* (DSM 14940 & DSM 14941); *Bacillus amyloliquefaciens subsp. plantarum* (D747); Equisetum; Garlic	available to replace copper before bloom and for control of fruit rots.
Oranges	DEUTTR dieback of citrus *Plenodomus tracheiphilus* PHYTSP brown rot of citrus *Phytophthora citrophthora* BOTSRI gummosis of citrus *Botryosphaeria ribis* DIAPCI gummosis of citrus *Diaporthe citri* CAPDC sooty mould of citrus *Capnodium citri* PSDMSY blast of Citrus *Pseudomonas syringae pv. syringae* PHYTCO brown rot of citrus *Phytophthora citrophthora* PHYUOL *Phyllocoptruta oleivora* PHYTNP root rot *Phytophthora nicotianae var. parasitica* PENIDI green mould of citrus fruits *Penicillium digitatum* COLLSP anthracnose, post-bloom fruit drop, tear stain and stem-end rot on fruit, or as wither-tip of twigs *Colletotrichum sp.*	Quicklime; Microorganisms; Bicarbonate; Equisetum; Sulphur; Polysulfide; Garlic	Alternatives not widely used; reduction potential probably not fully exploited.
Potatoes	PHYTIN late blight of potato *Phytophthora infestans* ERWICA bacterial soft rot of potato *Pectobacterium carotovorum subsp. Carotovorum* ALTESO early blight of potato *Alternaria solani*	Microorganisms; Bicarbonate; Equisetum; Sulphur; Polysulfide; Garlic	Alternatives not widely used and not considered efficient; reduction potential by resistant cultivars not fully exploited.
Lemons and limes	DEUTTR dieback of citrus *Plenodomus tracheiphilus* PHYTSP root rot *Phytophthora spp.* BOTSRI branch canker *Botryosphaeria ribis* DIAPCI gummosis of citrus *Diaporthe citri* CAPDC sooty mould of citrus *Capnodium citri* PSDMSY blast of citrus *Pseudomonas syringae pv. syringae*	Quicklime; Microorganisms; Bicarbonate; Equisetum; Sulphur; Polysulfide; Garlic	No appropriate alternative available to control bacterial diseases.

Cherries	STIGCA shoot blight of cherry *Wilsonomyces carpophilus* MONIFG brown rot of fruits *Monilinia fructigena* MONILA European brown rot of stonefruit *Monilinia laxa* XANTCA bacterial canker of stone fruits *Xanthomonas arboricola pv. pruni* AGRBTU crown gall *Agrobacterium tumefaciens* BLUMJA anthracnose of cherry *Blumeriella jaapii* PSDMMP bacterial canker of stone fruits *Pseudomonas syringae pv. morsprunorum* TRANP red rust of stone fruit *Tranzschelia pruni-spinosae* PUCCCE rust of cherry *Puccinia cerasi* MONIFC American brown rot of stone fruits *Monilinia fructicola* TAPHWI witches' broom of cherry *Taphrina wiesneri*	Bicarbonate; Equisetum; Sulphur; Polysulfide; Aluminium sulfate	Reduction potential exploited in most areas. No appropriate alternative available to control bacterial diseases.
Kiwi	PSDMSP canker of kiwi *Pseudomonas syringae pv. actinidiae* PHYTCC *Phytophthora cactorum*	*Bacilllus amyloliquefaciens*; Microorganisms; Bicarbonate; Equisetum; Sulphur; Polysulfide; Garlic	Alternatives not widely used; reduction potential probably not fully exploited.
Brassicas	ALTEBA dark spot of crucifers *Alternaria brassicae* XANTCA brown rot of brassicas *Xanthomonas campestris pv. campestris* PSDMMS lettuce marginal leaf blight *Pseudomonas marginalis pv. marginalis* LEPTMA black leg of crucifers *Plenodomus lingam* ERWICA bacterial soft rot of vegetables *Pectobacterium carotovorum subsp. carotovorum*	NaHCO3	Lack of alternatives for control of bacterial diseases.
Apricots	TAPHDE leaf curl of peach *Taphrina deformans* VALSCI dieback of stone fruit *Valsa cincta* VALSLE canker of apricot *Valsa leucostoma* SPHRPA *Podosphaera pannosa* GNOMER leaf scorch of stonefruit *Apiognomonia erythrostoma* VENTCA scab of apricot *Venturia carpophila* STIGCA shothole of stonefruit *Wilsonomyces carpophilus* XANTPC *Xanthomonas prunicola* PSDMSX bacterial blast *Pseudomonas syringae* TRANPS red rust of stone fruit *Tranzschelia pruni-spinosae* FUSCAM canker of peach *Diaporthe amygdali* XANTPR bacterial canker of stone fruits *Xanthomonas arboricola pv. pruni*	Lime sulphur (needs derogation); Potassium bicarbonate ; *Bacillus amyloliquefaciens ; Bacillus subtilis*	Alternatives have very limited activity and are barely used.
Pears	PHYTCC collar rot of pear *Phytophthora cactorum* NECTGA Nectria canker *Neonectria ditissima* VENTIN apple scab *Venturia inaequalis* VENTPI scab of pear *Venturia pyrina*	Sulphur; Laminarin*;* Potassium bicarbonate; Lime sulphur; *Aureobasidium pullulans; Bacilllus amyloliquefaciens;*	Copper reduction potential based on available alternatives is fully exploited in most countries; no adequate solutions available to

	PSDMSX pear blossom blast *Pseudomonas syringae* VALSLE Valsa canker *Valsa leucostoma* ERWIAM fire blight *Erwinia amylovora* AGRBTU crown gall disease *Agrobacterium tumefaciens* VENTPI scab of pear *Venturia pyrina* MYCOPY ashy leaf spot of pear *Mycosphaerella pyri* GYMNFU trellis rust of pear *Gymnosporangium sabinae* MONIFG brown rot *Monilinia fructigena* DIPCML Marssonina blotch of apple *Diplocarpon mali* BOTSOB bark necrosis of pome fruits *Botryosphaeria obtusa* CYTOSP pear Cytospora canker *Cytospora sp.* BOTRCI grey mould *Botryotinia fuckeliana* PEZIAL bitter rot Phlyctema vagabunda, *Gloeosporium album* PENIEX blue mould *Penicillium expansum* PLEOAL pear brown spot *Pleospora allii*	*Bacillus subtilis* (QST 713); Myco Sin (Aluminium Sulfate + *Equisetum arvense*)	replace copper before bloom and for control of fruit rots.
Tomatoes	PHYTIN late blight of tomato *Phytophthora infestans* ALTELY stem canker of tomato *Alternaria alternata f. sp. lycopersici* FULVFU leaf mould of tomato *Mycovellosiella fulva* SEPTLY blight of tomato *Septoria lycopersici* PSDMSX *Pseudomonas syringae* PSDMTM bacterial speck of tomato *Pseudomonas syringae pv. tomato* ALTESP stem canker of tomato *Alternaria arborescens* CORBMI bacterial canker of tomato *Clavibacter michiganensis subsp. michiganensis* SEPTLY blight of tomato *Septoria lycopersici*	*Bacillus amyloliquefaciens subsp. plantarum* (D747); *Bacillus subtilis* (QST 713); Sodium bicarbonate; Microorganisms; Equisetum; Sulphur; Polysulfide; Garlic	Alternatives not widely used and not considered efficient; reduction potential probably not yet fully exploited.
Greenhouse tomatoes	PHYTIN late blight of tomato *Phytophthora infestans* BOTRCI grey mould *Botryotinia fuckeliana* FULVFU leaf mould of tomato *Mycovellosiella fulva* ALTESO early blight of tomato *Alternaria solani* SEPTLY blight of tomato *Septoria lycopersici* XANTAV bacterial spot of tomato *Xanthomonas axonopodis pv. vesicatoria* PSDMTM bacterial speck of tomato *Pseudomonas syringae pv. tomato* CORBMI bacterial canker of tomato *Clavibacter michiganensis subsp. michiganensis* SEPTLY blight of tomato *Septoria lycopersici*	Microorganisms; Equisetum; Sulphur; Polysulfide; Garlic	Alternatives not widely used and not considered efficient; reduction potential probably not yet fully exploited.
Greenhouse cucumber	PSPECU downy mildew of cucurbits *Pseudoperonospora cubensis* PSDMLA bacterial spot of cucurbits *Pseudomonas syringae pv. Lachrymans*	none	Poor efficacy of copper and lack of alternatives.

Hops	PSPEHU downy mildew of hop *Pseudoperonospora humuli*	Myco Sin (Aluminium Sulfate + *Equisetum arvense*)	Alternative not widely used due to limited activity.

[a] EPPO codes according EPPO (2021) EPPO Global Database (available online). https://gd.eppo.int

Table S2. Approval of copper compounds as active substances in different European countries (status 2019, source: European database on permission of active substances and national databases).

Copper active substance	Country																												Total
	AT	BE	BG	CH	CY	CZ	DE	DK	EE	EL	ES	FR	FI	HR	HU	IE	IT	LT	LU	LV	MT	NL	NO	PL	PT	RO	SE	SI	SK	UK	
Bordeaux mixture		x		x	x					x		x			x		x				x				x	x		x			11
Copper hydroxyde	x	x	x	x	x	x	x			x	x	x		x	x		x	x	x	x	x			x	x	x		x	x		22
Copper oxide					x					x	x	x		x	x		x						x	x	x			x			11
Copper oxychloride	x	x	x	x	x	x	x			x	x	x		x	x	x	x		x		x				x	x		x	x	x	21
Tribasic copper sulphate	x		x	x	x	x	x			x	x	x		x	x		x		x						x	x		x	x		17

AT Austria, BE Belgium, BG Bulgaria, CH Switzerland, CY Cyprus, CZ Czechia, DE Germany, DK Denmark, EE Estonia, EL Greece, ES Spain, FI Finland, FR France, HR Croatia, HU Hungary, IE Ireland, IT Italy, LT Lithunia, LU Luxemburg, LV Latvia, MT Malta, NL Netherlands, NO Norway, PL Poland, PT Portugal, RO Romania, SE Sweden, SI Slovenia, SK Slovakia, UK United Kingdom.

Table S3. Organically managed horticultural area (temperate fruits, grapes, olives, nuts, vegetables including potato) in 2017 in Europe, in the twelve surveyed countries, and in the three European countries with the largest organically managed area (Spain, Italy, France).

	ha	percentage
Sum all European countries	1457615	
Sum 12 surveyed countries	1213343	83
Sum Spain, Italy, France	1099266	75

Table S4. Development of the organic area between 2004 and 2017 for crops and countries with the highest annual copper consumption.

		Organic area (ha)			
Country	Year	Almonds	Grapes	Nuts	Olives
Bulgaria	2006	-	227	146	-
	2017	-	4'091	18'065	-
France	2004	-	16'428	0	0
	2017	-	78'502	17'782	4'736
Hungary	2004	-	579	3'024	-
	2017	-	1'716	2'502	-
Italy	2004	0	31'170	8'766	88'936
	2017	13'984	105'384	30'733	235'741
Spain	2004	0	14'928	0	90'024
	2017	123'817	106'896	23'644	195'113
Total	**2004**	**0**	**63'332**	**11'936**	**178'960**
	2017	**137'801**	**296'589**	**92'726**	**435'590**