



## **Pathways to phase-out contentious inputs from organic agriculture in Europe**

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Factsheets for stakeholders (WP PLANT)

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## 1. Summary

This deliverable presents four Factsheets for stakeholder's uptake on: transfer/adaptation of available alternatives to contentious inputs for citrus, olives, tomato and aubergine protection in organic farming in the Mediterranean region. Each factsheet is available on the Organic-PLUS website [www.organic-puls.net](http://www.organic-puls.net).



## Pathways to phase-out contentious inputs from organic agriculture in Europe

Organic-PLUS is an EU Horizon 2020 project involving 25 partners in 12 countries (EU and non-EU), working to find alternatives to some of the contentious inputs currently permitted in certified organic production, including copper fungicides, mineral oils and sulphur, with a special focus on perennial Mediterranean crops such as citrus and olives, and greenhouse crops like tomato and aubergine

# WHAT ARE THE ALTERNATIVES TO CONTENTIOUS INPUTS IN MEDITERRANEAN ORGANIC CITRUS GROWING?

## CITRUS



This factsheet provides an overview of some alternative treatments and methods to replace or reduce the use of contentious inputs (namely copper, mineral oils and sulphur) that are used to control diseases and pests in citrus crops. Alternative compounds cannot be considered as one-for-one substitutes of contentious inputs, but they should be integrated within more complex strategies for crop protection. In general, plant health should rely on preventive and indirect care measures in preference to off-farm inputs. The choice of varieties adapted to local conditions, the use of resistant varieties and other general measures which ensure a resilient agricultural system, strongly contribute to reduce dependency on external inputs to control pests and diseases.

The citrus industry is one of the most important fruit industries worldwide. The Mediterranean countries are second only to China for fruit production, and are the largest fruit exporter after South Africa (FAO 2016). However, the citrus yield is threatened by pathogens and pests, which limit productivity in the field and also the shelf life of fruit post-harvest. In addition to common and often devastating phytopathogenic fungi and bacteria (*Plenodomus tracheiphilus*, *Phytophthora* spp., *Fusarium* spp., *Penicillium* spp., *Pseudomonas syringae*) commonly found in Mediterranean regions, recent infections caused by *Colletotrichum* spp. and *Alternaria* spp. strongly compromise citrus production in different Mediterranean countries. These can be considered to be emerging diseases which could become a serious limiting factor for citrus growers in the future.

In organic citrus orchards, pathogens are primarily controlled by the regular spraying of copper-based products. The demonstrated noxious effect of copper [Cu] on soil microbial communities and other soil fauna has led to regulatory restrictions in its use in the EU. The use of copper for crop protection purposes has been permitted in the EU to a maximum amount of 6 kg/ha/yr of metal Cu up to the end of 2018 but was reduced to 4 kg/ha/yr starting from January 2019.

According to data collected in interviews of experienced advisors in the first 6 months of the Organic-PLUS project, the old limit was, on the whole, acceptable to Mediterranean citrus growers. The only exception is in regard to lemons. Many alternative compounds to reduce or replace copper inputs are under development, but few are currently available on the market.

This project has received funding from the European Union's Horizon 2020 impact and innovation programme under grant agreement No. 774340



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# WHAT ARE THE ALTERNATIVES TO CONTENTIOUS INPUTS IN MEDITERRANEAN ORGANIC CITRUS GROWING?

## ALTERNATIVES TO COPPER

The previous limit of 6 kg/ha/year of copper was generally considered acceptable among organic citrus farmers and advisors surveyed in 2018. The only exception was for lemons which are particularly susceptible to Mal secco disease. Since no effective alternatives to copper are available against this disease, in years with adverse weather conditions, the new limit (4 kg/ha/year or 28 kg over 7 years from 01/01/2019) may not be considered sufficient by some organic growers.

### Alternatives to copper currently in use:

**Low copper grade formulations**, with reduced copper content (2-6%), allow a smaller amount of copper to be applied per hectare.

**Natural alternative formulations**, applied to replace or reduce copper dosage, used alternately or in combination with copper. Some of them are included in Annex II to Commission Regulation (EC) 889/2008, permitted for plant protection in organic crop production.

- **Plant extracts** with biocidal properties and which stimulate plant defences.
- **Inorganic substances**: fatty acids, potassium salts and potassium hydrogen carbonate.
- **Biological control agents** with a variety of mechanisms of action against fungal and bacterial pathogens and which have a stimulating effect on plant defences. (such as *Trichoderma* spp.).
- **Seaweed extracts** such as *Ascophyllum nodosum* and *Laminaria digitata*. Laminarin extracted from *L. digitata* does not have a bactericidal or fungicidal effect, but enhances plants' resistance to pathogens.
- **Chitosan**, a natural polymer derived from chitin, reported to be directly effective against a variety of microorganisms, coupled with the stimulation of plant defence mechanisms.
- **Essential oils**: commercial formulations of citrus essential oils are approved for use in organic systems.

**Authors:** Andrivon, D., Cirvilleri, G., de Cara, M., Katsoulas, N., Kir, A.



## ALTERNATIVES TO MINERAL OILS

Mineral oils are applied in citrus orchards to control insects and mites. Their use ranges between 30-100 litres/ha/year. The wide spectrum of effectiveness of mineral oils makes them more versatile than other alternatives which currently include:

- **Soft potassium soaps 28%**
- **Plant defence stimulants**
- **Beneficial predator species including:** *Aphytis melinus*, *Cryptolaemus montrouzieri*, *Leptomastix dactylopi*, *Amblyseius andersoni*, *Phytoseiulus persimilis*

## ALTERNATIVES TO SULPHUR

The use of sulphur in Mediterranean citrus crops is generally low and restricted to certain circumstances. Application rates range between 3-6 kg/ha/year.

No alternatives are currently known to be in use.

## Main goals of Organic-PLUS in relation to citrus

In laboratory and growth chamber tests, biological control agents, resistance inducers, innovative formulations, vegetable extracts, GRAS (hydrogen peroxide; potassium bicarbonate; calcium polysulphide) will be evaluated as alternatives to Cu against *Colletotrichum* spp., *Alternaria* spp., *Penicillium* spp. and *Pseudomonas syringae*.

The best of these products will then be tested in open field trials and monitored for 2 years. These trials will evaluate: (a) rate of incidence/severity, (b) susceptibility to diseases, (c) impact on crop production, (d) best application strategy (e) synergic activity between products and (f) phytotoxicity.



## Pathways to phase-out contentious inputs from organic agriculture in Europe

Organic-PLUS is an EU Horizon 2020 project involving 25 partners in 12 countries (EU and non-EU), working to find alternatives to some of the contentious inputs currently permitted in certified organic production, including copper fungicides, mineral oils and sulphur, with a special focus on perennial Mediterranean crops such as citrus and olives, and greenhouse crops like tomato and aubergine

## WHAT ARE THE ALTERNATIVES TO CONTENTIOUS INPUTS IN MEDITERRANEAN ORGANIC OLIVE GROWING?

### OLIVES



This factsheet provides an overview of some alternative treatments and methods to replace or reduce the use of contentious inputs (namely copper, mineral oils and sulphur) that are used to control diseases and pests in citrus crops. Alternative compounds cannot be considered as one-for-one substitutes of contentious inputs, but they should be integrated within more complex strategies for crop protection. In general, plant health should rely on preventive and indirect care measures in preference to off-farm inputs. The choice of varieties adapted to local conditions, the use of resistant varieties and other general measures which ensure a resilient agricultural system, strongly contribute to reduce dependency on external inputs to control pests and diseases.

Olive trees are a defining characteristic of the Mediterranean landscape. Ancient olive groves, intensive olive plantations and even monumental olive trees are a key part of the cultural heritage and culinary traditions of the region. Europe has around 5 million hectares of olive trees, which worldwide account for 70 to 75% of all olive oil production and more than one third of table olives.

Yields are threatened by a variety of pathogens and pests, which limit productivity in the field and post-harvest shelf life. Common phytopathogenic fungi and bacteria (*Colletotrichum gloeosporioides*, *Spilocaea oleaginea*, *Mycocentrospora cladosporioides*, *Verticillium* spp., *Pseudomonas savastanoi*) commonly found throughout the Mediterranean region compromise olive production. In addition, there is a new threat; *Xylella fastidiosa*, a quarantine bacterium under Commission Implementing Decision [EU] 2018/927, in the Salento area of southern Italy. This emerging disease represents a new and serious threat to olive growers in the region.

In organic olive orchards, pathogens are mainly controlled by regular spraying with copper-based products. The demonstrated noxious effect of copper on soil microbial communities and other soil fauna has led to regulatory restrictions of its use in the EU. The use of copper for crop protection purposes was permitted in the EU to a maximum amount of 6 kg/ha/yr of metal Cu up to the end of 2018 but was reduced to 4 kg/ha/yr from January 2019.

According to data collected by interviewing experienced advisors in 2018, the old 6 kg limit was found to be acceptable to the majority of olive growers.

Many alternative compounds to reduce or replace copper use are under development, but few are currently available on the market and even fewer are being used by growers to any significant extent.

This project has received funding from the European Union's Horizon 2020 impact and innovation programme under grant agreement No. 774340



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# WHAT ARE THE ALTERNATIVES TO CONTENTIOUS INPUTS IN MEDITERRANEAN ORGANIC OLIVE GROWING?

## ALTERNATIVES TO COPPER

For Mediterranean olive crops, the previous copper limit of 6 kg/ha/year was generally accepted.

**Low copper grade formulations**, with reduced copper content (2-6%), allow a smaller amount of copper to be distributed per hectare.

**Natural alternative formulations**, applied to replace or reduce copper dosage, used alternatively or in combination with copper. Some of them are included in Annex II to Commission Regulation (EC) 889/2008, permitted for plant protection in organic crop production.

- **Inorganic substances**: sprayable zeolite and Kaolin for abiotic stress protection and olive fruit fly protection;  $K_2SiO_3$ .
- **Plant defence stimulators**, including calcium and silicon.
- **Biological control agents**, with a variety of mechanisms of action against fungal and bacterial pathogens and stimulating effects on plant defenses. *Trichoderma* spp., *Bacillus subtilis* strains, *Glomus* spp. are some example of BCAs available on the market.
- **Chitosan**, a natural polymer obtained from chitin, reported active against a variety of microorganisms, with a good direct effect combined with stimulation of plant defence mechanisms.
- **Compost/compost teas**: compost tea enriched with Oriental Plane leaves (*Platanus orientalis*), vermicompost and vermicompost tea.
- **Lime-sulphur**, used as a spray to control fungal infections with some effect on insects and bacteria.



## ALTERNATIVES TO MINERAL OILS

Mineral oils derived from petroleum are applied to control insects and mites. Their application ranges between 30-90 litres/ha/year. Though not widely used in olives, their wide spectrum of effectiveness makes them more versatile than their alternatives:

- **Organic oils** (e.g. rapeseed)
- **Zeolite and Kaolin** for olive fruit fly protection

## ALTERNATIVES TO SULPHUR

The use of sulphur in Mediterranean olive groves is generally low, approximately 15-20 kg/ha/year.

No alternatives are currently adopted.

## Main goals of Organic-PLUS in relation to olives

Alternatives to Cu (lime sulphur, plant defence stimulators, products based on Ca and Si, natural extracts) will be tested in open field trials and monitored for 2 years.

Field trials will evaluate: (a) incidence/severity, (b) susceptibility to diseases, (c) impact on crop production and fruit quality, (d) best application strategy, and (e) phytotoxicity.

Effectiveness of other alternatives to Cu (*Glomus intradices*,  $K_2SiO_3$ , *Bacillus subtilis* EU007, compost tea enriched with *Platanus orientalis* leaves, Maxicrop, moldy bread peaces) will be evaluated in comparison with  $CuSO_4$  both in growth chamber and, for more promising treatments, in the open field. Timings of promising alternative applications will be determined by means of a disease forecasting system that will be established on the field trial area.

**Authors:** Andrivon, D., Cetinel, B., Cirvilleri, G., de Cara, M., Katsoulas, N., Kir, A.





## Pathways to phase-out contentious inputs from organic agriculture in Europe

Organic-PLUS is an EU Horizon 2020 project involving 25 partners in 12 countries (EU and non-EU), working to find alternatives to some of the contentious inputs currently permitted in certified organic production, including copper fungicides, mineral oils and sulphur, with a special focus on perennial Mediterranean crops such as citrus and olives, and greenhouse crops like tomato and aubergine

## WHAT ARE THE ALTERNATIVES TO CONTENTIOUS INPUTS IN MEDITERRANEAN ORGANIC TOMATO GROWING?

### TOMATO



This factsheet provides an overview of some alternative treatments and methods to replace or reduce the use of contentious inputs (namely copper, mineral oils and sulphur) that are used to control diseases and pests in citrus crops. Alternative compounds cannot be considered as one-for-one substitutes of contentious inputs, but they should be integrated within more complex strategies for crop protection. In general, plant health should rely on preventive and indirect care measures in preference to off-farm inputs. The choice of varieties adapted to local conditions, the use of resistant varieties and other general measures which ensure a resilient agricultural system, strongly contribute to reduce dependency on external inputs to control pests and diseases.

Tomato plants are widely cultivated in European countries, for use both as table tomatoes for fresh consumption and for industrial tomato processing (primarily canning).

Cultivation takes place in both the open ground and in greenhouses, based on the location and time of year.

Yields are continually under threat from a range of pathogens and pests which limit productivity in the field and also the shelf life of tomatoes post-harvest. Common and often devastating phytopathogenic fungi and bacteria (powdery mildews, *Phytophthora infestans*, *Cladosporium* spp., *Botrytis cinerea*, *Alternaria* spp., *Pseudomonas* spp., *Xanthomonas* spp.) are present across the Mediterranean region and can compromise tomato production.

In organic tomato cultivation, pathogens are generally controlled by the regular spraying of copper-based products. The demonstrated noxious effect of copper on soil microbial communities and other soil fauna has led to regulatory restrictions of its use. Copper for crop protection purposes was permitted at a maximum rate of 6 kg/ha/yr in the EU until the end of 2018, but from January 2019, this was reduced to 4 kg/ha/yr.

According to interviews conducted with experienced advisors as part of the Organic-PLUS project in 2018, the old limit was widely regarded as acceptable among Mediterranean tomato growers.

Many alternative compounds to reduce or replace the use of copper are in development, but few are currently available on the market.

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# WHAT ARE THE ALTERNATIVES TO CONTENTIOUS INPUTS IN MEDITERRANEAN ORGANIC TOMATO GROWING?

## ALTERNATIVES TO COPPER

Copper use in Mediterranean countries has rarely exceeded the previous limit of 6 kg/ha/year. The greatest use of copper for tomatoes is in greenhouses during the winter season. Alternatives to copper currently include:

**Low copper grade formulations**, with a reduced copper content (2-6%), result in a smaller amount of copper being applied per hectare.

**Natural alternative formulations**, applied to replace or reduce copper dosage, used alternately or in combination with copper. Some of them are included in Annex II to Commission Regulation (EC) 889/2008, permitted for plant protection in organic crop production:

- **Plant extracts** with biocidal activity and stimulating effects on plant defences.
- **Inorganic substances**: fatty acids, potassium salts and potassium hydrogen carbonate.
- **Biological control agents**, with a variety of mechanisms of action against fungal and bacterial pathogens and stimulating effects on plant defenses. *Ampelomyces quisqualis*, *Bacillus subtilis*, *B. amyloliquefaciens*, *Pseudomonas* spp., *Trichoderma* spp. and *Streptomyces* spp., are examples of BCAs currently available to growers.
- **Seaweed extracts** such as *Ascophyllum nodosum* and *Laminaria digitata*. Laminarin extracted from *L. digitata* does not have a direct bactericidal or fungicidal activity, but enhances the plants' resistance to pathogens.
- **Chitosan**, a natural polymer obtained from chitin, is reported to be active against a variety of microorganisms. It has an effective direct action but also stimulates plants' defence mechanisms.
- **Herbal preparations**, including decoctions of nettle (*Urtica dioica*) and horsetail (*Equisetum* ssp.).



## ALTERNATIVES TO MINERAL OILS

Mineral oils are occasionally applied to tomatoes to repel insects and mites. The maximum dose is 10-13 litres/ha/year. Alternatives include:

- **Organic oils (e.g. rapeseed)**
- **Plant defence stimulators**
- **Diatomaceous earth**
- **Potassium salts or fatty acids**
- **Natural predators of pests**



## ALTERNATIVES TO SULPHUR

Sulphur is applied in organic greenhouses against pests and powdery mildews. Its use can move from 2 kg/ha/year to, in the rare and highest case, 95 kg/ha/year depending on the production system and the incidence of pests/diseases. It is not selective and has harmful effects on beneficial arthropods. Alternatives, not widely applied for economical reasons, are essentially represented by:

- **Maltodextrins**
- **Potassium hydrogen carbonate**
- ***Ampelomyces quisqualis***

## Main goals of Organic-PLUS in relation to tomato

Based on practitioners experience, ten different available-to-growers formulations alternative to copper will be screened in the lab for their efficacy against pathogenic tomato strains of *Botrytis cinerea* and *Fulvia fulva*. The effective formulations will be checked for persistence of their effect. The best selected alternative will be tested out in three demonstrative trials carried out in Mediterranean greenhouses.

Authors: Andrivon, D., Cirvilleri, G., de Cara, M., Katsoulas, N., Kir, A.



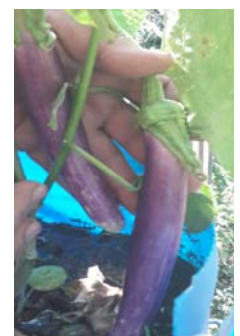


## Pathways to phase-out contentious inputs from organic agriculture in Europe

Organic-PLUS is an EU Horizon 2020 project involving 25 partners in 12 countries (EU and non-EU), working to find alternatives to some of the contentious inputs currently permitted in certified organic production, including copper fungicides, mineral oils and sulphur, with a special focus on perennial Mediterranean crops such as citrus and olives, and greenhouse crops like tomato and aubergine

## WHAT ARE THE ALTERNATIVES TO CONTENTIOUS INPUTS IN MEDITERRANEAN ORGANIC AUBERGINE GROWING?

### AUBERGINE



This factsheet provides an overview of some alternative treatments and methods to replace or reduce the use of contentious inputs (namely copper, mineral oils and sulphur) that are used to control diseases and pests in citrus crops. Alternative compounds cannot be considered as one-for-one substitutes of contentious inputs, but they should be integrated within more complex strategies for crop protection. In general, plant health should rely on preventive and indirect care measures in preference to off-farm inputs. The choice of varieties adapted to local conditions, the use of resistant varieties and other general measures which ensure a resilient agricultural system, strongly contribute to reduce dependency on external inputs to control pests and diseases.

Aubergine (also known as eggplant) is a crop widely grown in southern European countries. Cultivation is practised both in open fields and in greenhouses, dependent on the location and time of year.

Aubergine yields are threatened by fungal and bacterial diseases which limit both productivity in the field and the shelf life of the crop post-harvest.

Fungi and bacteria (powdery mildews, *Phytophthora infestans*, *Botrytis cinerea*, *Verticillium* spp., *Rhizoctonia solani*, *Alternaria solani*, *Xanthomonas* spp.) present in the Mediterranean region may compromise aubergine production in the various countries that they are grown.

In organic aubergine cultivation, pathogens are generally controlled by regular spraying of copper-based products. The demonstrated noxious effect of copper on soil microbial communities and other soil fauna has led to regulatory restrictions to its use. The use of copper for crop protection purposes was permitted in the EU up to a maximum of 6 kg/ha/yr of metal Cu until the end of 2018 but from January 2019 this was reduced to 4 kg/ha/yr.

According to data collected during interviews with experienced advisors in the first 6 months of the Organic-PLUS project, the previous 6 kg limit was widely accepted by Mediterranean aubergine growers.

Many alternative compounds to reduce or replace copper are under development, but few are currently available on the market, and fewer still are in use to any significant extent.

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# WHAT ARE THE ALTERNATIVES TO CONTENTIOUS INPUTS IN MEDITERRANEAN ORGANIC AUBERGINE GROWING?

## ALTERNATIVES TO COPPER

**Low copper grade formulations**, with reduced copper content (2-6%), allow a smaller amount of copper to be distributed per hectare.

**Natural alternative formulations**, applied to replace or reduce copper dosage, used alternately or in combination with copper. Some of them are included in Annex II to Commission Regulation (EC) 889/2008, permitted for plant protection in organic crop production:

- **Plant extracts** with biocidal activity and stimulating effects on plant defences.
- **Inorganic substances**: fatty acids, potassium salts and potassium hydrogen carbonate.
- **Biological control agents (BCAs)** with a variety of mechanisms of action against fungal and bacterial pathogens, coupled with the stimulation of plant defences. *Ampelomyces quisqualis*, *Bacillus* spp., *Pseudomonas* spp. and *Trichoderma* spp. are some example of BCAs currently available.
- **Seaweed extracts**, such as *Ascophyllum nodosum* and *Laminaria digitata*. Laminarin extracted from *L. digitata* does not have a direct bactericidal or fungicidal action, but enhances plant resistance to pathogens.
- **Chitosan**, a natural polymer obtained from chitin is reported to be active against a variety of microorganisms. As well as this direct action, plant defence mechanisms are also stimulated.
- **Compost/compost teas**: compost tea, vermicompost, vermicompost tea.
- **Resistant varieties**: some native aubergine varieties can be resistant or moderately resistant to fungal diseases such as early blight (*Alternaria solani*). It is this aspect that Organic-PLUS will be exploring further for aubergines.



## ALTERNATIVES TO MINERAL OILS

Mineral oils are rarely applied to aubergines and only for their repellent effect against insects or mites. Alternatives to mineral oils include:

- **Potassium salts of fatty acids**
- **Plant defence stimulators**

## ALTERNATIVES TO SULPHUR

Sulphur is applied in organic greenhouses against pests and powdery mildew. It is not selective and has harmful effects on beneficial arthropods. There are alternatives, but these are not currently applied for economic reasons. They include:

- Maltodextrins
- *Ampelomyces quisqualis* (a fungal biocontrol that is a hyperparasite of powdery mildews)

## Main goals of Organic-PLUS for aubergine

Organic-PLUS will focus on finding varieties of aubergine with strong resistance to fungal disease. 60 aubergine landraces will be screened for early blight (*Alternaria solani*). Seedlings of the landraces will then be tested for resistance to *Alternaria solani* fungal spores in climate-controlled conditions. After the inoculation stage, resistant or moderately resistant native races will be selected.

**Authors:** Andrivon, D., Cetinel, B., Cirvilleri, G., de Cara, M., Katsoulas, N., Kir, A.

