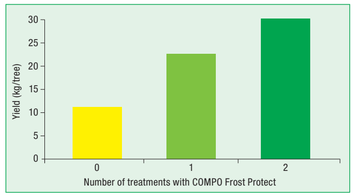
Synergistic action of the COMPO Frost Protect ingredients in frost damage prevention

COMPO Frost Protect and its components have been tested in numerous experiments.

Fig. 5: **Yield of "Boskoop" apple trees as affected by freeze injury and pretreatment with COMPO Frost Protect**



Wölfel and Noga, 1998

In field experiments in the Rhine Valley yield of apple trees was significantly higher after one or two treatments with COMPO Frost Protect as compared to the untreated control.

COMPO Frost Protect effectively prevents apple flowers from spring frost damage. Note that only the combination of the antioxidant α-tocopherol and the croprotectant PEG provides optimal protective effect against frost.

Tab. 3: **Percentage of central flowers as damaged by artificial freezing (3h at –1.8°C and 1h at T_{min} = –3.0°C) of field-grown flowering "Boskoop" branches**

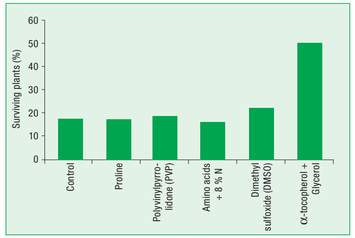
Time of application before freezing (h)	Control	α-tocopherol	PEG*	α-tocopherol + PEG
Freeze-injured flowers				
4	81	71	80	90
24	81	66	69	16
48	81	92	84	32

* Polyethylene glycol

Noga and Schmitz, 1998

Young tomato plants survived frost period after treatment with α-tocopherol and PEG.

Fig. 6: **Cryoprotector treatments in tomato plants**



(24h after cooling down to –4°C)
Modified after Moratiel et al. 2011

Fig. 7: **Apple fruits growing at the bottom parts of the tree after a severe frost night in April (orchard in the Rhine Valley, Germany)**

COMPO EXPERT

Application recommendations

COMPO Frost Protect contains active ingredients which have to be taken up by the plant surface and will be active after having reached the target tissue. In most cases this process requires up to 24 hours from the application time on. Thus it is strongly recommended to spray COMPO Frost Protect at least 24 hours before the expected frost period. The higher level of anti-frost agents in the crop tissue will last for about 7 to 10 days. After this period it will be necessary to repeat the application.

Spraying should be done when there is a high probability for a frost incidence during a sensitive stage of the crop. Frost will never be completely predictable but own observations or the forecast provided by local frost alert services reduce the risk to a minimum.

Source: Image by courtesy of Spray-Trac Systems Ltd

It is recommended to apply COMPO Frost Protect in a quantity of 1.2 liter solution per hectare. To ensure the ideal concentration of the active ingredients 1.2 liter of COMPO Frost Protect should be dissolved in 200 liters of water (= 0.6%).
For single plant treatments prepare also 0.6% solutions and spray until the whole plant is wet.
Split applications at lower concentrations, for example two times 0.6 liters per hectare at an interval of 5 to 7 days will extend the effective time period.

It is also possible to combine COMPO Frost Protect with other frost protection methods such as sprinkler irrigation. In this case it should be made sure that COMPO Frost Protect can be absorbed for a period of at least 24 hours before the sprinkler system is turned on.

Finally it has to be pointed out that a balanced nutrition of the crop and the optimal irrigation schedule greatly support the efforts to shelter the crop from frost damage.

COMPO Frost Protect

- prevents valuable crops from frost damage due to its physiologically active ingredients
- saves the grower from significant yield losses

COMPO Frost Protect for

Fruit crops: COMPO Frost Protect(s) fruit tree flowers from late spring frosts

Vegetables and ornamental crops: COMPO Frost Protect(s) young plants during cold spells

Grapevine and forest trees: COMPO Frost Protect(s) young shoots and leaves from frost after prior warmer periods

Folder Frost 2012

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COMPO EXPERT

EXPERTS FOR GROWTH

COMPO Frost Protect

Prevents frost damage in valuable crops due to its physiological active ingredients

Protects the grower from significant yield losses

Most high value crops such as fruit trees, grapevines and vegetables are susceptible to freezing temperatures. In only a few minutes a frost event during late spring can destroy all the flowers of a fruit tree or kill a whole field of young vegetable plantlets. As a consequence frost incidents often result in significant yield or quality losses.

What happens when crops are subjected to frost?

Frost has two major effects on growing plant tissues:

1. **A general stress reaction** resulting in the formation of reactive oxygen species (ROS) and free radicals in the plant tissue. ROS, for example H_2O_2 or $O_2^{\cdot-}$, cause the oxidation of cell membranes and finally lead to cell death.

2. **Ice formation in the tissue.** Tissues will be damaged by frost if there is ice formation inside the cells whereas ice formation in the intercellular space (cell walls) is less harmful. Ice formation depends on various factors such as ambient air temperature and humidity during the freezing hours as well as on the plant's fitness.

Fig. 1: **Frost damage in apple flowers: Style and ovaries turn brown and die off (right side)**

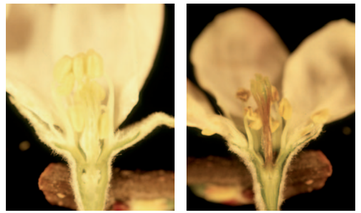

Fig. 2: **Quality relevant frost damage in apple fruits: "Frost Ring" (left) and "Frost Tongue" (right)**

Chilling and frost mean stress for the crop

Oxidative stress (Frost, Heat, Radiation, …)	Plant response:
↓	
Formation of ROS and free radicals (H_2O_2 or $O_2^{\cdot-}$) →	**Formation of antioxidants**
↓	↓
Damage of cell membrane	Neutralization of free radicals
↓	↓
Loss of cell functionality	Preservation of cell functionality
↓	↓
Death of the cell	**No damage**

Effect of oxidative stress and plant response

Plants respond to oxidative stress with the formation of antioxidants, which eliminate ROS and prevent the cell membranes from disintegration. The most effective antioxidants in plants are α-tocopherol (vitamin E) and phenolic acids.
The major function of α-tocopherol is to keep the cell membranes functionable even under severe environmental stress like frost. α-tocopherol is also the most effective natural antioxidant: 1 molecule of α-tocopherol inactivates up to 220 radical molecules!

Once cells are frozen they loose their functionality and die. This damage results in necrotic tissues and severe quality losses of fruits. If reproductive organs (flowers, young fruits) are affected, there is a strong risk of total yield losses.
Ice crystals inside the cytoplasm destroy the intracellular structures, which are mainly built by membranes. Frost damages can be minimized by cryoprotectants which inhibit the formation of ice crystals.

The most frost-sensitive plant parts are open flowers (fruit trees), new shoots (grapevines, ornamental plants). Also young plantlets (vegetable crops) are very susceptible to frost.

Tab. 1: **Critical temperatures of apple flowers at different phenological stages**

Phenological Stage	Critical Temperature °C
Mouse Ear	< –4
Green Bud	–3
White/rose Bud	–2
Full Bloom	–1

Tab. 2: **Critical temperatures for grapevine shoots at different phenological stages**

Phenological Stage	T_{10} (°C)	T_{90} (°C)
1st Swell	–10.6	–19.4
Bud Burst	–3.9	–8.9
1st Leaf	–2.8	–6.1
2nd Leaf	–2.2	–5.6
3rd Leaf	–2.2	–3.3
4th Leaf	–2.2	–2.8

T_{10} = 10% flowers killed
T_{90} = 90% flowers killed
(Temperatures were developed in chamber studies; for transfer to field conditions values should be slightly higher)
After Snyder and Melo-Abreu 2005

COMPO Frost Protect – How does it work?

COMPO Frost Protect has been created to prevent flowers and other susceptible plant parts from frost damage. It combines cryoprotectants with the most effective natural anti-stress compound α-tocopherol and the stabilizing nutrient boron.

COMPO Frost Protect

Components:
- α-DL-tocopherol
- Cryopotectants
- Boron (2%)
- Specific adjuvants to ensure uptake and enhanced efficincy

COMPO Frost Protect is a borated fertilizer in suspension.

Specific weight: 1.05 kg/l
pH: 7.4

Fig. 3: **Synergistic action of the COMPO Frost Protect ingredients in frost damage prevention**

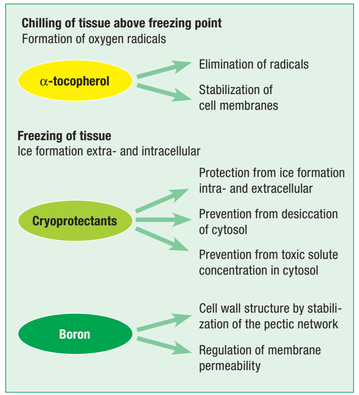

Fig. 4: **Frost damage on Lonicera nitida: left untreated, right treated with COMPO Frost Protect**