Nano.T® CaPO

Better fruit quality

and shelf life with **nano-calcium**

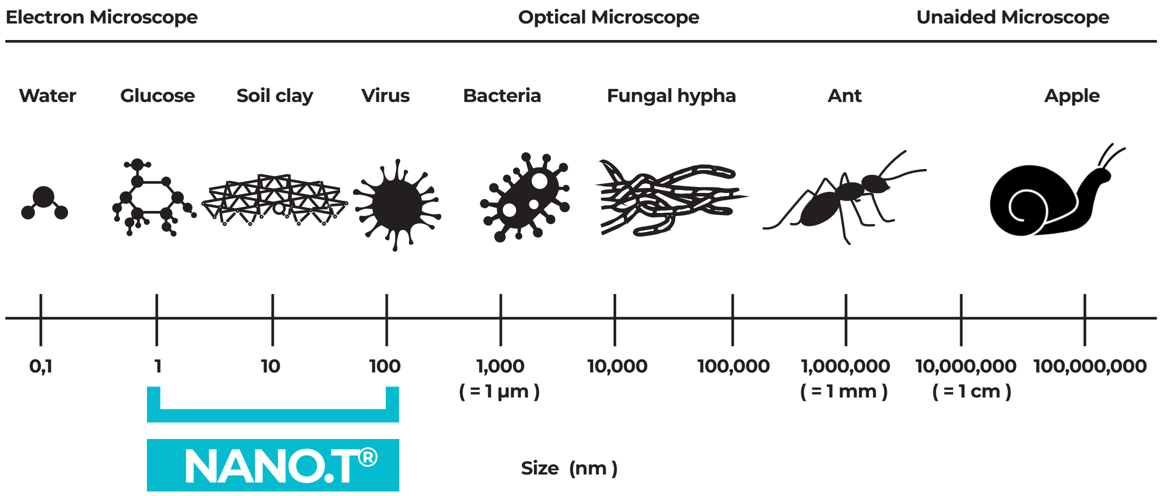
FABBRICA
COOPERATIVA
PERFOSFATI
CEREA

Traditional agriculture
and innovative technological projects:
The Nanonutrition plant

NANO.T®

The technology which allows to produce nanofertilizers smaller than 100 nm.

NANO.T® is the technology developed and patented by FCP Cerea, in collaboration with the University of Verona, allowing us to produce highly efficient nano-fertilizers.
Nanoparticles represent an easily available nutritional source as compared to the same formula of larger dimensions



1 nanometer = one billionth of a meter (nm = 1m*10^{-9})

1. High efficiency

Nanoparticles have an elevated contact surface, which easens dissolution and absorption in the plant, allowing a reduced dosage of use;

2. Stability in the formulation

The patented production process allows to obtain a stable colloidal suspension over time, avoiding precipitation or aggregation;

3. Long-lasting action

Products obtained through the NANO.T® process can be employed in the most difficult environmental conditions without altering their characteristics;

4. Low environmental impact

Nano-fertilizers do not leach on the soil and have the ability to adhere to the leaf without dispersing in the environment and requiring a limited number of applications;

5. Innovative patented technology

The NANO.T® technology is an innovation born from a collaboration between the R&D department of FCP Cerea and the department of Biotechnology of the University of Verona.

NANO.T® CaPO

FRUIT QUALITY AND SHELF-LIFE

NANO. T ® CaPO contains high-efficiency calcium that thanks to the colloidal formulation of nanoparticles is distributed evenly on the plant and is poorly washable. Calcium is quickly absorbed and conveyed to the fruits contributing to improve their quality and shelf life.
NANO. T CaPO prevents and cures calcium deficiencies (apical rot, cracking, bitter buttering, tipburn) and helps to strengthen plant tissues.

Benefits:

- High efficiency at low dosage: the nanoparticles and thanks to the size hundreds of times smaller than that of the other products, have a high contact surface area and are evenly distributed on the leaves and fruits facilitating their absorption.
- Persistent on the plant and fruit: the formulation in colloidal suspension allows a better adhesion to the foliar waxes;
- It is easy to use because it can be mixed with the main plant protection products.

FORMULATION

P Ca K

Title and composition

Phosphous (P_2O_5)	Potassium (K_2O)	Calcium (CaO)	pH
4% (1)	5,5% (2)	4,5% (1) 2% (2)	3,5

(1) total - (2) water soluble

Dosages and uses

Crop	Dosages	Period
Stone fruits	2,5-5 l/ha	fruit enlargement, veraison
Pome fruits	2,5-5 l/ha	fruit set, fruit enlargement, veraison
Kiwi	2,5-5 l/ha	fruit set, fruit enlargement, 20 days before harvest
Table grapes	2,5-5 l/ha	pre-flowering, berries peper corn-size, veraison, 15 days before harvest
Tomato	2-4 l/ha	pre-flowering, after fruit set, veraison
Melon, zucchini, cucumber	2-4 l/ha	after fruit set, fruit enlargement
Leaf vegetables	2-3 l/ha	15 days post-transplant, 15 days before harvest

PACKAGING

TYPOLOGY

LIQUID

Effectiveness of Nano-Ca in Table Grapes:
A valuable ally to increase the shelf-life and reducing grapes detachment

Table grapes are highly susceptible to berry abscission post-harvest, especially **during storage and transportation**.
This is a physiological process associated with senescence and can be triggered by various factors, such as changes in photoperiod, wounding, pathogen attack, and water stress.
Hormones -particularly **auxin and ethylene**- play a crucial role in regulating abscission.

The detachment process is mediated by specialized cells located in the apical zone, known as the **abscission zone (AZ)**, a distinct group of cells capable of perceiving the abscission signal and initiating organ detachment.

The importance of nano-Ca

Calcium not only serves as a structural component (for plant growth and development), but plays a vital role in maintaining the cell wall and positively influencing the detachment process in the abscission zone.

It helps improve the firmness and elasticity of the tissues, allowing the fruit to preserve itself even after handling, cold treatments, and the presence of pathogens, and to achieve a longer post-harvest shelf life.

Its deficiency leads to physiological disorders that affect the quality and marketing of the final product.

Calcium chloride in its traditional form is poorly mobile within the plant. It is absorbed by the roots and, through the xylem vessels, tends to settle on the leaves involved in photosynthesis, only reaching a small amount of the fruit through transpiration.
If applied to leaves, it tends to stick to their surfaces.

Nano calcium, however, applied foliarly, has the ability to enter the plant systemically. It can be directly absorbed by the fruit or transported to it via the phloem vessels.

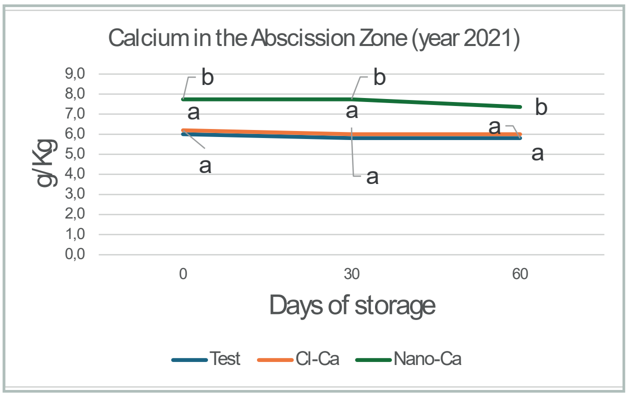
Trial carried out on “Thompson Seedless” grapes (seedless) in 2020 and 2021*

This test aimed to empirically demonstrate the effects of nanocalcium in the post-harvest phase of table grapes, particularly with regard to berry detachment and their shelf life.

Two different strategies were compared: one with **nano-calcium** (nano-Ca) and one with traditional **calcium chloride**, sprayed two weeks before harvest. The results were then analyzed at three different time points: at harvest, after 30 days, and after 60 days.

The data reported refers only to 2021, as they are similar to those of the previous year, in order to make the text easier to use; the graphs are an adaptation of the source.

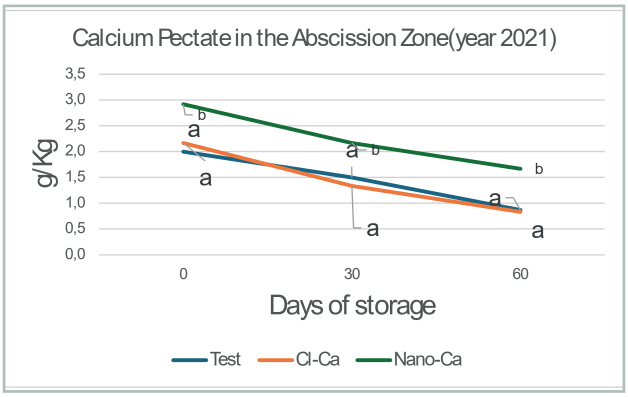
Calcium content in the abscission zone



From Figure 1 it can be seen that the calcium content in the abscission zone is consistently higher when nano-calcium is applied.

Figure 1 - Calcium content in the abscission zone. Different letters indicate significant differences (P ≤ 0.05).

One of calcium’s primary functions in plants is the formation of pectates, chemical compounds that are integral to the structure of plant cell walls. **In the abscission zone**, the presence of **calcium pectate** strengthens the cell wall, helping to delay structural collapse caused by physiological changes.



Data from the trial on Thompson Seedless grapes (Figure 2) show that calcium pectate content in the abscission zone is significantly higher following **nano-calcium (nano-Ca) application.**
This indicates that bunches treated with nano-Ca exhibit greater resistance to detachment.

Figure 2 - Calcium pectate content in the abscission zone. Different letters indicate significant differences (P ≤ 0.05).

Ethylene production rate in the abscission zone

The test shows that, after harvest, ethylene production increases steadily, but when Nano-Ca is applied, this amount is still lower than when Cl-Ca is applied and in the control group (Figure 3).

From these results, it can be deduced that the use of nano-Ca resulted in a significant reduction in ethylene production.

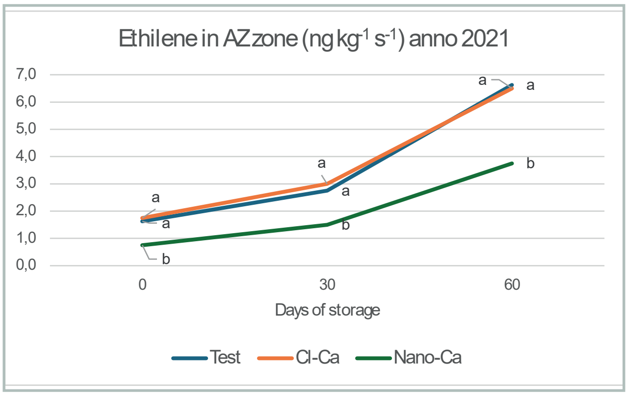


Figure 3 - Ethylene content in the abscission zone. Different letters indicate significant differences (P ≤ 0.05).

Ethylene is an endogenous hormone that has crucial effects on fruit development, plant ripening (aging), and its abscission point.
Calcium regulates ethylene production, reducing the tendency for berries to detach.

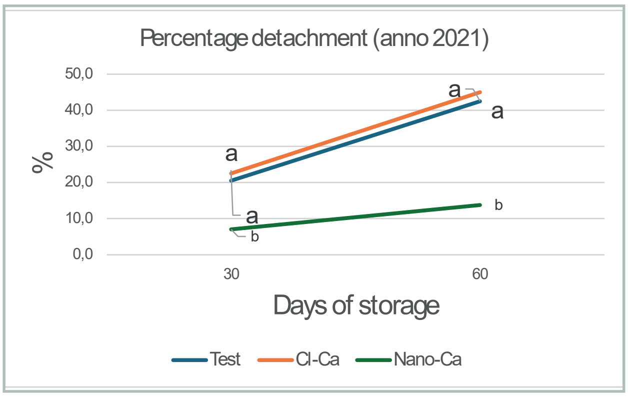


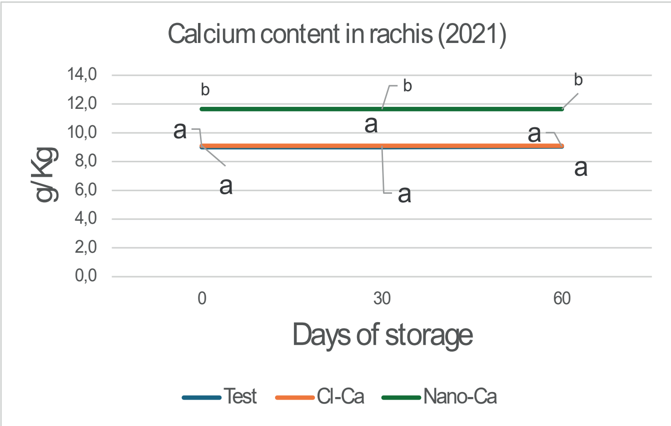
Figure 4 - Percentage of detachment iof berries. Different letters indicate significant differences (P ≤ 0.05).

Percentage of detachment

The percentage of berry detachment gradually increases over time for all three groups, but this increase is smaller when **Nano-Ca** is applied (Figure 4).

Calcium content in the rachis and fruit

In Figure 5 it can be seen that, following the foliar application of nano-calcium, the content of the latter in the rachis and in the fruit is higher.



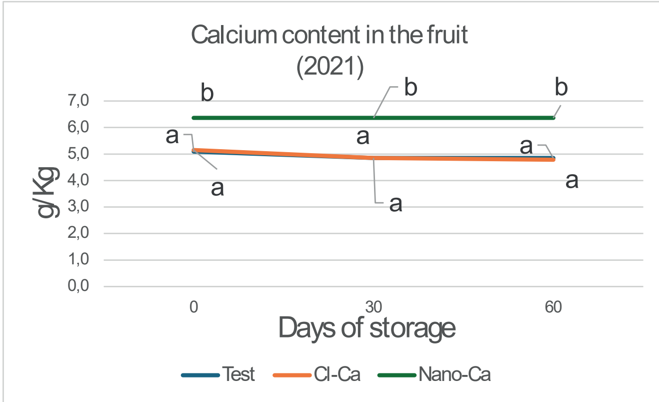
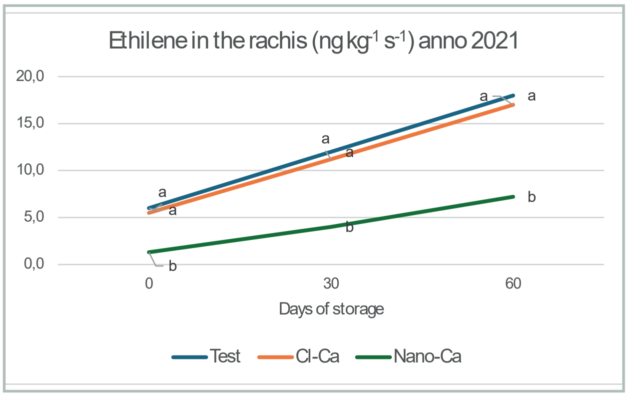


Figure 5 - Calcium content in rachis and fruit. Different letters indicate significant differences (P ≤ 0.05).

Ethylene production in the rachis and fruit was also lower in the control treated with nano-calcium (Figure 6).



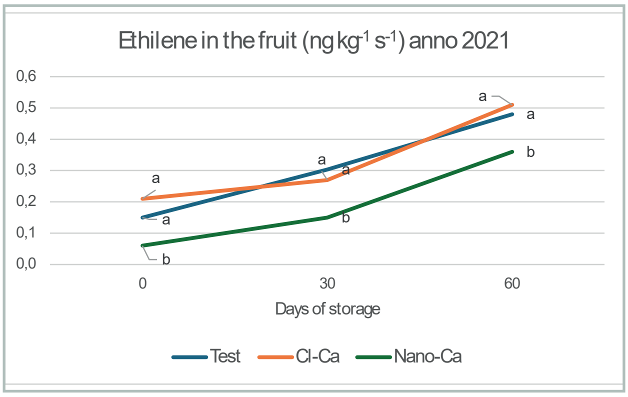


Figure 6 - Ethylene production in the rachis and fruit. Different letters indicate significant differences (P ≤ 0.05).

The application of nano-calcium therefore contributes significantly to the improved consistency and firmness of the fruit. The reduced ethylene production leads to a lower amount of water-soluble pectins, thus contributing to the firmness of the berries.

Final thoughts

- **Increased calcium** content in the berries, rachis, and abscission zone. This is because nano-Ca, compared to traditional calcium-based fertilizers, is more easily absorbed by the plant.
- **Inhibition of ethylene production induced by calcium content**
- **Increased calcium pectate content**
- **Maintained a low percentage of berry detachment**
- **Increased fruit hardness and shelf life after harvest**

**Mingtao Zhu et.al. (2024). Preharvest Nano-calcium Reduces the Table Grape Berry Abscission by Regulating Ethylene Production During Storage. Journal of Plant Growth Regulation 43:1400–1409*

Effectiveness of Nano-Calcium in Nectarines: Reduces Fruit Cracking and Enhances Sweetness and Shelf Life

Compared to peaches, nectarines are more prone to fruit cracking—a physiological disorder also observed in other crops such as grapes, cherries, and pomegranates.

In some cases, **this issue is caused primarily by physical factors**, such as sudden changes in temperature or fluctuations in water content within the fruit.

In other cases, cracking appears to be associated with elevated levels of **abscisic acid (ABA)** in the pericarp. In less tolerant cultivars, which naturally tend to accumulate higher levels of ABA, f**oliar treatments with auxins and gibberellins are often applied in an attempt to inhibit the effects of this hormone.**

The importance of nano-Ca

Among the minerals, the most crucial for combating cracking is undoubtedly **calcium**, which, in the form of calcium pectate, contributes to the structure of the **middle lamella.**

Several studies have shown that a **higher calcium content in the pericarp (skin) corresponds to a lower likelihood of fruit cracking.** This can also be induced through foliar treatments with calcium-based formulations, which help thicken the skin and limit the action of certain enzymes whose activity deteriorates pectins

What is the middle lamella?

It is a thin, gelatinous layer present between adjacent cell walls of plant cells and is mainly composed of pectins, which bind the cells together.

In this context, the use of nano-Ca (nutrients between 1 and 100 nm) is particularly interesting, as the **small particle size makes these fertilizers highly active and easily absorbed and translocated within the plant.**

Test Conducted on Nectarines in 2020 and 2021*

This study aimed to analytically assess the role of nano-calcium in reducing fruit cracking in nectarines. For this purpose, a cultivar particularly susceptible to cracking was selected.

The trial was first conducted in 2020 and repeated in 2021, using two treatment groups (with three replicates each), consisting of nine plants per group, all grown under identical conditions. In the first group, a foliar application of 0.5 g/L of nano-calcium was administered 20 and 30 days after flowering (DAF). The second group received only distilled water as a control. At 35, 45, and 60 days after flowering, samples were collected from each group: 20 fruits, 20 leaves, and 20 grams of stem phloem were randomly selected from the nine trees in each trial. These samples were analyzed to assess calcium content in leaf, peel, pulp, and phloem tissues.

The data presented here refer only to the 2021 trial, as they were consistent with the results obtained in 2020. This choice was made to simplify data presentation. The graphs shown are adapted from the original source.

Effetti sul cracking

The following study shows that **nano-Ca limits cracking to a much greater extent than standard calcium** (about 5% versus almost 30%) and this makes it a very attractive solution for all growers (Figure 1).

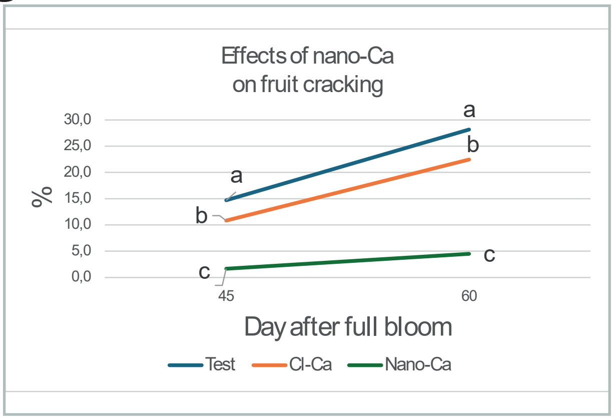


Figure 1. Effects of calcium chloride and nano-Ca treatments on nectarine fruit cracking. Data are means ± SE of three replicates. Different letters indicate significant differences (P ≤ 0.05).

Calcium content in the peel

From Figures 2 and 3, it can be observed that **nano-Ca treatment increased the calcium content in the peel, and the calcium pectate in the peel** also increased significantly (P ≤ 0.05).

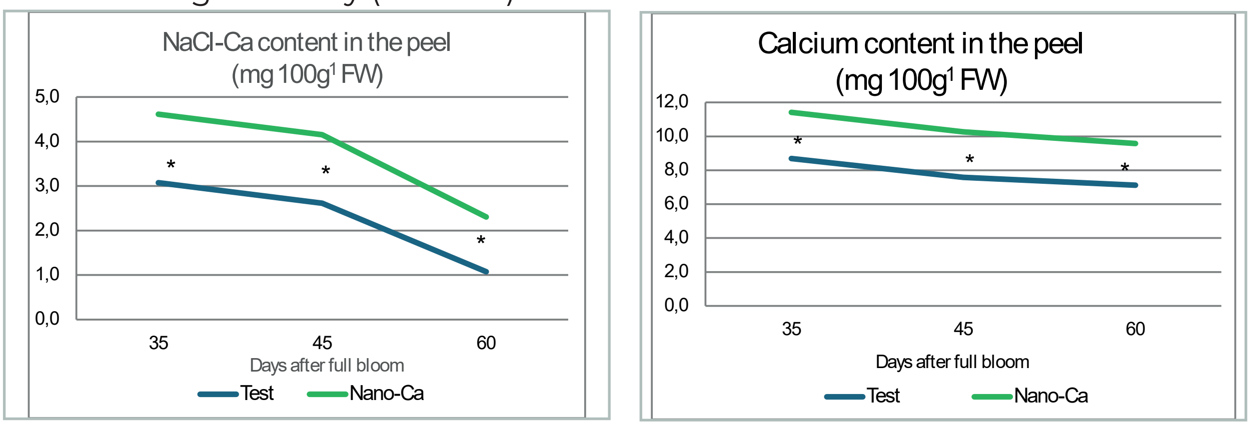


*Figure 2 - Effect of nano-Ca treatment on fruit peel calcium content and peel calcium pectinate content in 2021. Data are means ± SE of three replicates. * Asterisks represent significant differences (P ≤ 0.05).*

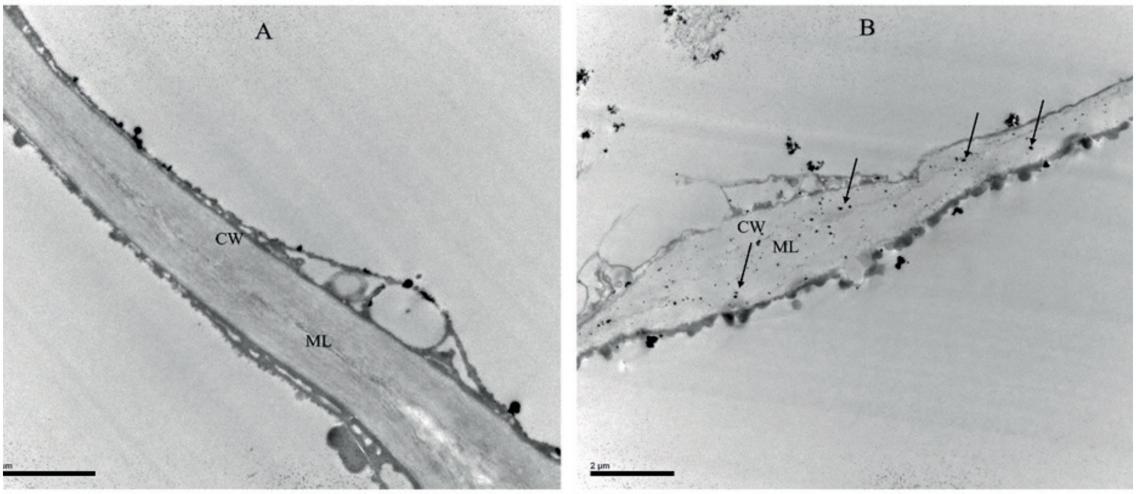
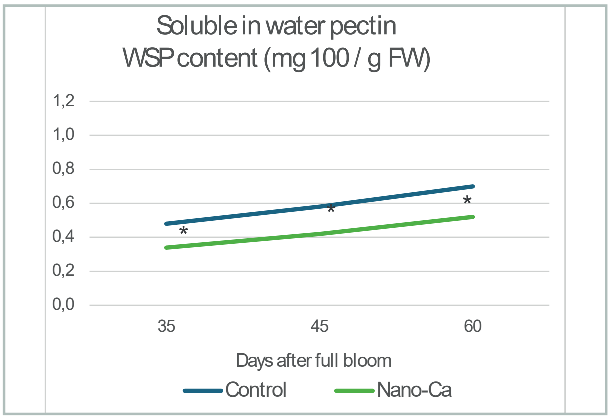
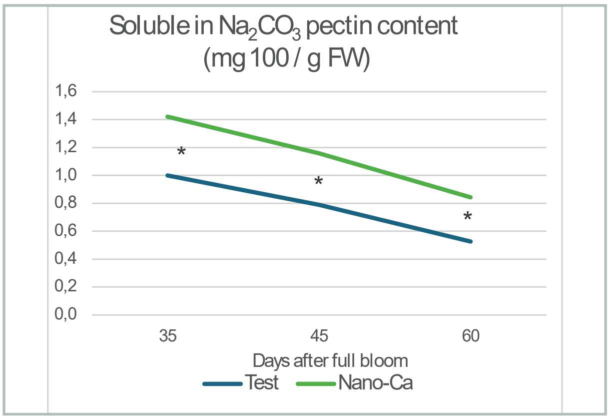


Figura 3 - Controllo (A) e trattamento con nano-Ca (B). Le frecce nere indicano i depositi di calcio presenti nella campione trattato.. CW, parete cellulare; ML, lamella mediana.

When looking at pectins, the **contents of the two less soluble ones (SSP and CSP) in the peel treated with nano-Ca are significantly higher** than those of the control, **while the content of water-soluble pectin (WSP) is lower than that of the control.**





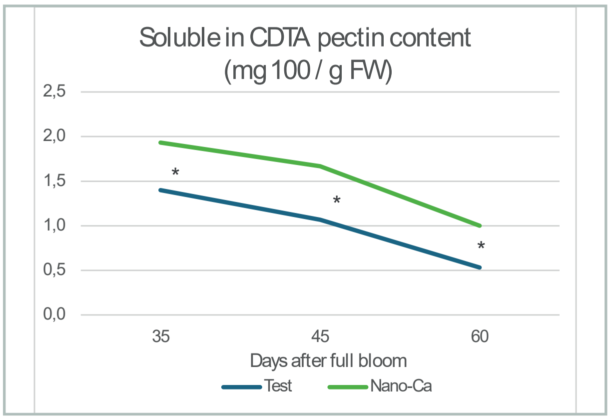


*Figure 4 - Effect of nano-Ca treatment on peel pectin composition in 2021: water-soluble pectin (WSP), Na_2CO_3-soluble pectin (SSP), and CDTA-soluble pectin (CSP). Data represent means ± SE of three replicates. *Asterisks represent significant differences ($P \leq 0.05$).*

Impact on Fruit Quality

During the first 45 days after flowering (DAF), **calcium treatments also enhance the activity of calmodulin**, a protein essential for intracellular signaling. Calmodulin regulates a wide range of cellular functions, including the synthesis of sugars and anthocyanins, which contribute to fruit sweetness and coloration.

Nano-calcium also has a notable impact on overall fruit quality. As shown in the table, treated fruits exhibit higher sugar content (sweetness) and increased levels of vitamin C (Vc), which plays important metabolic and antioxidant roles (Fig. 5).

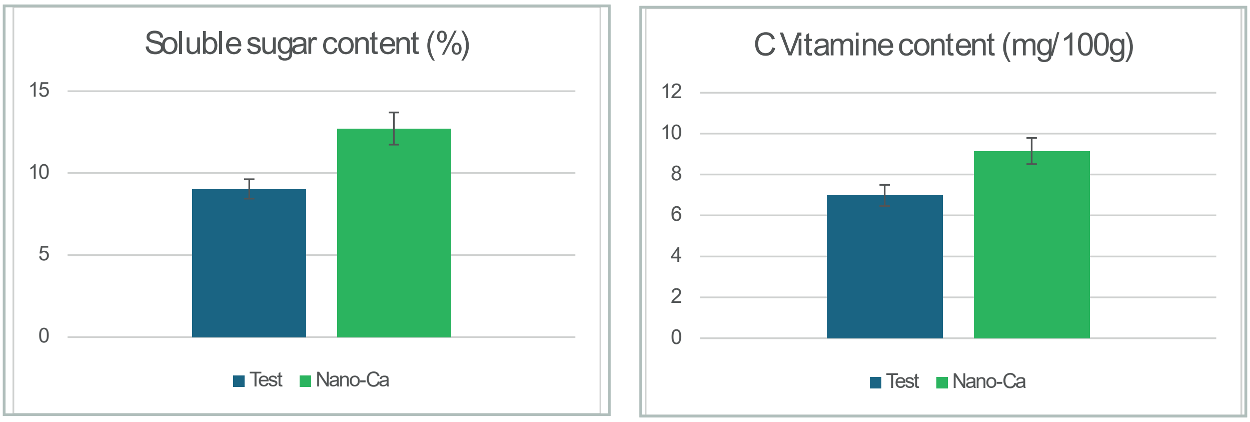


Figure 5 - Soluble sugar and C Vitamine in fruits

At 60 DAF, **the firmness of the fruit treated with nano-Ca was also significantly higher than that of the control** (P ≤ 0.05) (fig.6).

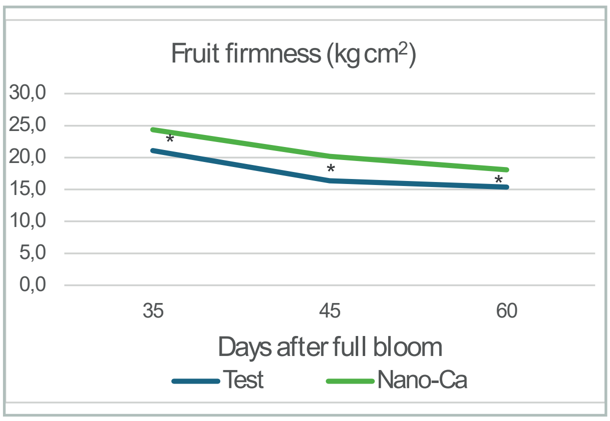


*Figure 6 - Effect of nano-Ca treatment on firmness of the fruits measured with a penetrometer. Data are means ± SE of three replicates. * Asterisks represent significant differences (P ≤ 0.005)*

Conclusions

Reduced fruit cracking is closely linked to calcium availability and, more specifically, to the formation of calcium pectate in the middle lamella of peel cell walls. The middle lamella plays a critical role in reinforcing intercellular connections, thereby improving peel elasticity and reducing the likelihood of cracking.

The study revealed that the number of calcium particles present in the middle lamella was significantly higher in nano-calcium–treated fruit compared to the control.

Additionally, calcium was observed to decrease cell membrane permeability, limiting water absorption by the peel and further reducing the risk of cracking.

A particularly noteworthy finding was the more regular and **compact arrangement of peel cells in fruit treated with nano-calcium** (Figure 7), which may also contribute to increased resistance to cracking.

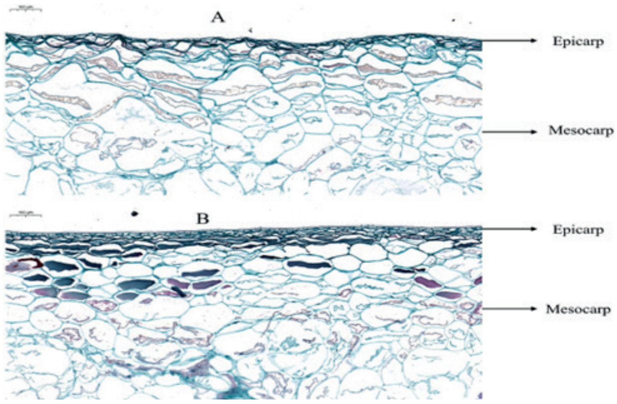


Figure 7. Observation of the peel microstructure at 45 DAFB in 2021. Control (A) and treatment with nano-Ca (B). In B the peel appears more regular and compact.

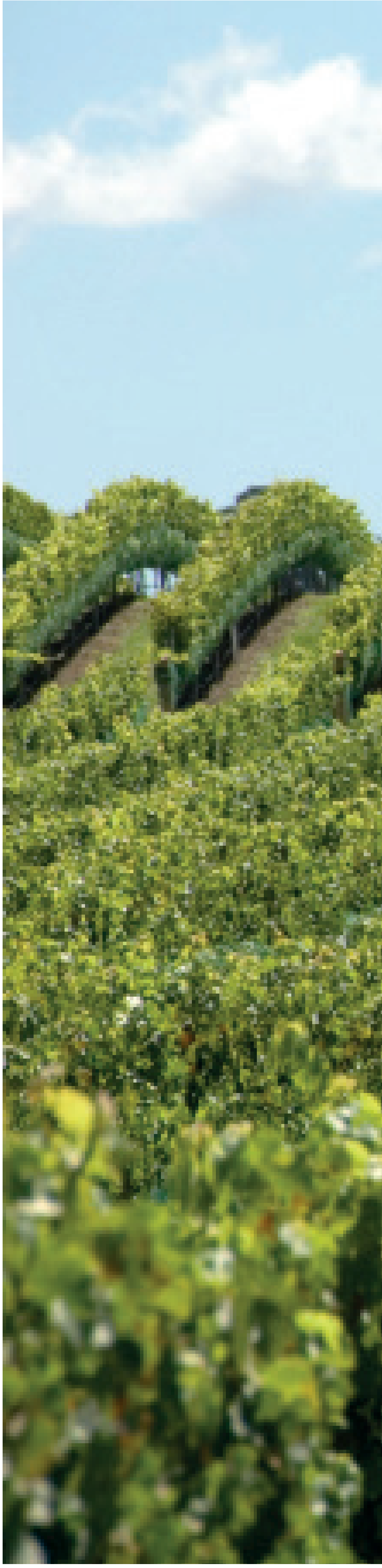
Furthermore, the data showed that **nano-Ca** enhances calmodulin activity in leaves and promotes the upregulation of genes involved in sucrose synthesis and phloem transport, **resulting in a significant increase in the fruit's soluble sugar content.**

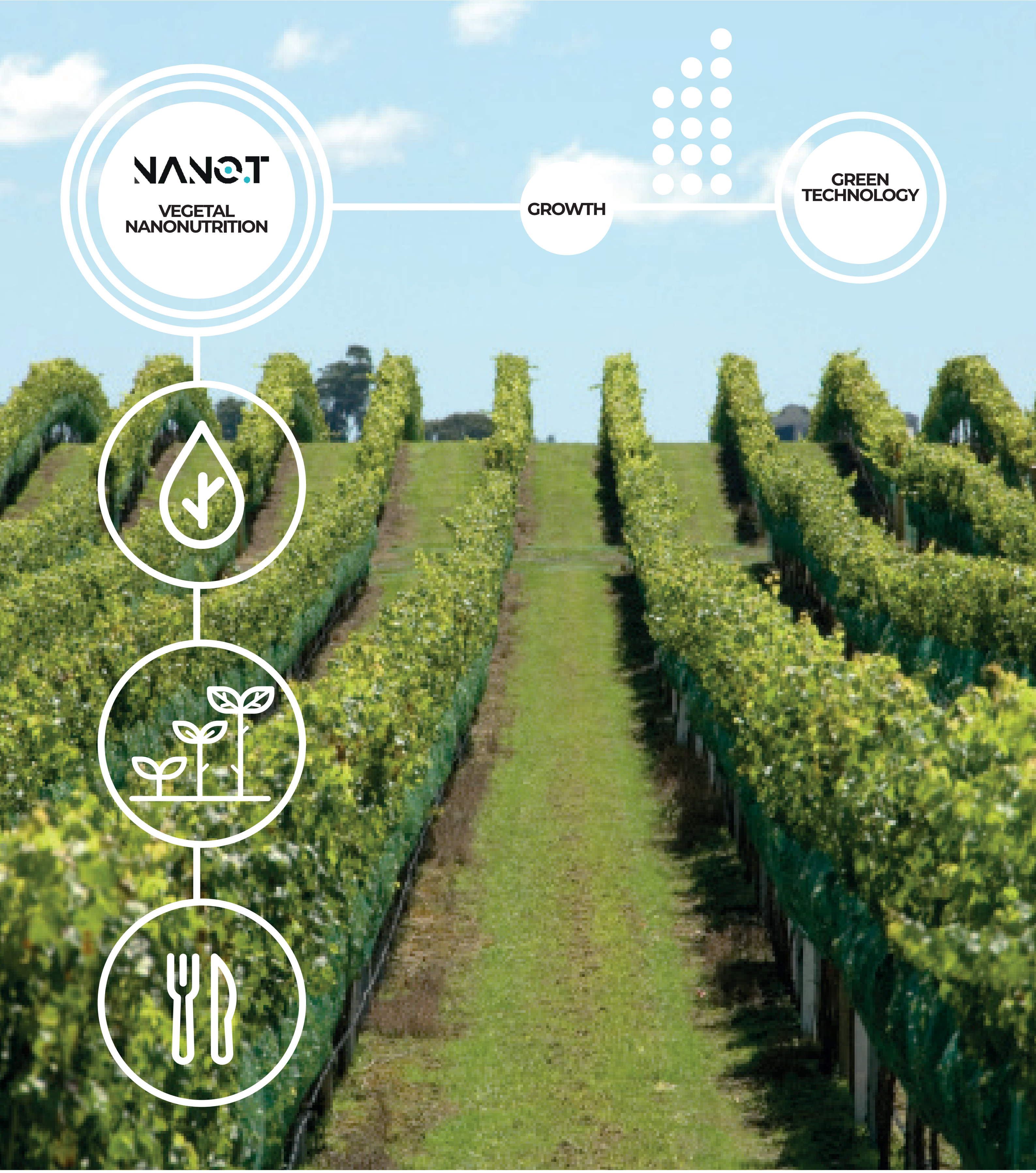
Altogether, these effects, combined with improved fruit firmness, contribute to superior overall fruit quality and extended shelf life.

** Mingtao Zhu et.al. (2023) Nano-calcium alleviates the cracking of nectarine fruit and improves fruit quality. Plant Physiology and Biochemistry 196 (2023) 370–380. Grafici riadattati dall'autore.*

Small things that make difference.

Nano-fertilizers: “green technology” that change the way to feed plants.

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