



# AgriSun Solutions pty ltd

CITRUS APPLICATION GUIDE

## Reflective Orchard Ground Film

Research-informed guidance  
for Clementines, mandarins,  
oranges and lemons

# 1. PURPOSE OF THIS GUIDE

Reflective orchard ground film changes the orchard light environment by redirecting a portion of available solar radiation upward from ground level.

In citrus, published research has investigated reflective ground treatments in relation to:

- reflected light,
- rind colour,
- soil temperature,
- fruit-quality characteristics,
- antioxidant activity,
- ascorbic acid,
- and broader orchard physiology.

However, citrus should **not** simply follow an apple application programme.

The crop physiology is different.

The commercial objective is different.

The cultivars are different.

And the published research does not establish one universal pre-harvest timing for all citrus.

This guide therefore separates:

## DIRECTLY PUBLISHED CITRUS RESEARCH

from

## SOUTH AFRICAN CULTIVAR-SPECIFIC TRIAL PRIORITIES.

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## 2. WHY CITRUS NEEDS ITS OWN PROGRAMME

In red apples, reflective film has often been studied as a final-stage colour-management treatment.

Citrus is more complex.

Depending on cultivar and production objective, a grower may instead be interested in:

- rind colour development,
- light reaching shaded fruit,
- canopy light distribution,
- fruit-surface temperature,
- soil/root-zone temperature,
- maturity,
- soluble solids,
- acidity,
- external quality,
- or another measurable production variable.

For this reason:

## CITRUS SHOULD NOT AUTOMATICALLY RECEIVE AN APPLE TIMING PROGRAMME.

A Gala four-week treatment, for example, should not simply be transferred to Nadorcott, Valencia or Eureka.

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## 3. CLEMENTINES

### CLEMENPONS CLEMENTINE

Clemenpons provides one of the most useful published citrus examples.

Research conducted in Valencia, Spain investigated reflective white plastic mulch in precocious ‘Clemenpons’ Clementine.

The researchers wanted to understand the relationship between the ground treatment, soil temperature and rind-colour development.

The mulch increased reflected light and reduced both maximum soil temperature and the daily soil-temperature range.

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## 4. THE IMPORTANT 70–30-DAY OBSERVATION

The researchers reported that the major differences between mulched and control treatments became established approximately:

### 70–30 DAYS BEFORE HARVEST.

This is valuable information.

But it must be interpreted correctly.

## THIS IS NOT A 70-DAY INSTALLATION RECOMMENDATION.

The study does **not** justify an AgriSun instruction stating:

**“Install reflective film 70 days before Clementine harvest.”**

The 70–30-day period describes when major differences between treatments in reflected light and soil-temperature conditions were observed.

It is therefore an **experimental observation**, not a universal installation window.

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## 5. WHAT THE CLEMENPONS RESEARCH ACTUALLY TELLS US

The useful finding is broader than timing.

Reflective white mulch changed:

### THE LIGHT ENVIRONMENT

and

### THE SOIL-TEMPERATURE ENVIRONMENT.

The study links those changes to rind-colour development in Clemenpons Clementine.

This tells AgriSun that a citrus trial should not look only at the fruit.

It may also be useful to monitor:

- reflected light,
- soil temperature,
- fruit colour,
- and maturity progression.

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## 6. WHERE REFLECTIVE FILM MAY BE RELEVANT IN CLEMENTINES

A controlled trial may be relevant where:

- rind colour develops unevenly,
- interior fruit differs from exposed fruit,
- canopy density limits light penetration,

- or growers want to investigate the relationship between orchard-floor reflection and colour development.

## PUBLISHED TIMING

**No universal installation timing should be published.**

The Clemenpons study provides a useful research framework, but the **70–30-day observation must not be presented as an AgriSun installation instruction.**

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# 7. WHAT TO MEASURE IN A CLEMENTINE TRIAL

## BEFORE INSTALLATION

Record:

- ☐ Cultivar
- ☐ Orchard block
- ☐ Expected harvest date
- ☐ Current rind colour
- ☐ Fruit-development stage
- ☐ Canopy density
- ☐ Row orientation
- ☐ Irrigation
- ☐ Existing sunburn
- ☐ Film position

## DURING THE TRIAL

Measure where practical:

- ☐ Reflected light
- ☐ Soil temperature
- ☐ Fruit-surface temperature
- ☐ Rind colour
- ☐ Canopy condition
- ☐ Irrigation status
- ☐ Weather conditions

## AT HARVEST

Compare:

- ☐ Rind colour
  - ☐ Soluble solids
  - ☐ Titratable acidity
  - ☐ Maturity index
  - ☐ Fruit weight
  - ☐ External defects
  - ☐ Sunburn
  - ☐ Commercial pack-out
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## 8. SOUTH AFRICAN CLEMENTINE TRIAL PRIORITY HIGH PRIORITY

A South African Clementine trial should establish:

- practical deployment timing,
- rind-colour response,
- changes in reflected light,
- soil-temperature response,
- fruit-temperature response,
- maturity,
- and pack-out.

The Spanish research gives us a good scientific starting point.

South African trials are needed to determine whether the same relationships are commercially useful under local conditions.

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## 9. MANDARINS

# NADORCOTT

## WHAT RESEARCH TELLS US

Reflective mulch research in citrus demonstrates that changing the orchard-floor surface can influence light and thermal conditions.

However, the Clemenpons study does **not** establish a Nadorcott application programme.

Nadorcott differs in:

- cultivar physiology,
- harvest period,
- rind-colour development,
- orchard architecture,
- and production conditions.

## WHERE REFLECTIVE FILM MAY BE RELEVANT

A trial may be worth considering where:

- rind colour is uneven,
- shaded fruit colours differently,
- dense canopy reduces interior light,
- or growers want to evaluate late-season canopy-light management.

## PUBLISHED TIMING

**No verified universal Nadorcott timing.**

AgriSun should not advertise:

**“Install Nadorcott film X weeks before harvest.”**

until cultivar-specific evidence exists.

## WHAT TO MEASURE

- rind colour,

- canopy position,
- Brix,
- acidity,
- maturity ratio,
- fruit weight,
- fruit temperature,
- sunburn,
- external defects,
- pack-out.

## **SOUTH AFRICAN TRIAL REQUIRED**

## **VERY HIGH PRIORITY**

Nadorcott should be one of AgriSun's priority citrus trials because it is commercially important and a measurable rind-colour response could be economically relevant.

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## **10. TANGO**

### **WHAT RESEARCH TELLS US**

Tango should not automatically inherit the Clemenpons programme.

The available citrus literature supports the principle that reflective ground treatments can alter orchard light conditions, but there is not enough cultivar-specific evidence to prescribe an AgriSun Tango timing.

### **WHERE REFLECTIVE FILM MAY BE RELEVANT**

Potentially where:

- rind colour is inconsistent,
- fruit inside the canopy remains different from exposed fruit,
- or growers are evaluating canopy-light management.

### **PUBLISHED TIMING**

**None that AgriSun should currently publish as universal.**

## **WHAT TO MEASURE**

- rind colour,
- maturity,
- Brix,
- acidity,
- fruit weight,
- canopy position,
- fruit temperature,
- sunburn,
- pack-out.

## **SOUTH AFRICAN TRIAL REQUIRED**

## **YES**

A local trial should establish whether reflective-film use produces a measurable commercial response and what treatment period is appropriate.

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## **11. NOVA**

### **WHAT RESEARCH TELLS US**

Nova should also be treated independently.

Direct Clemenpons results cannot be converted into a Nova recommendation.

### **WHERE REFLECTIVE FILM MAY BE RELEVANT**

Potentially where growers observe:

- poor interior colour,
- uneven rind development,
- shaded fruit,
- or a measurable difference between canopy positions.

## **PUBLISHED TIMING**

**No cultivar-specific AgriSun timing established.**

## **WHAT TO MEASURE**

- colour,
- Brix,
- acidity,
- maturity,
- fruit size,
- fruit temperature,
- sunburn,
- external defects,
- pack-out.

## **SOUTH AFRICAN TRIAL REQUIRED**

# **YES**

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## **12. WHY MANDARIN CULTIVARS NEED INDIVIDUAL TRIALS**

Nadorcott, Tango and Nova may all be grouped commercially as mandarins or mandarin hybrids, but that does not mean their response to reflected light will be identical.

They differ in:

- maturity timing,
- natural rind colour,
- canopy habit,
- orchard environment,
- and commercial harvest requirements.

Therefore:

# ONE MANDARIN $\neq$ ALL MANDARINS.

AgriSun should develop cultivar-specific recommendations from local data rather than copying a single timing across the category.

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## 13. ORANGES

### NAVEL ORANGES

#### WHAT RESEARCH TELLS US

Reflective ground treatments have been investigated across citrus systems, but the available evidence does not provide a robust Navel-specific AgriSun installation timing.

#### WHERE REFLECTIVE FILM MAY BE RELEVANT

Potentially where:

- rind colour differs between shaded and exposed fruit,
- dense canopies reduce lower/interior light,
- or growers want to investigate a light-management objective.

#### PUBLISHED TIMING

No universal Navel timing established.

#### WHAT TO MEASURE

- rind colour,

- fruit weight,
- Brix,
- acidity,
- maturity ratio,
- fruit temperature,
- sunburn,
- external quality,
- pack-out.

## **SOUTH AFRICAN TRIAL REQUIRED**

# **YES**

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## **14. VALENCIA**

### **WHAT RESEARCH TELLS US**

Valencia oranges should not automatically receive a Clementine or apple programme.

The available evidence does not justify one universal AgriSun timing.

### **WHERE REFLECTIVE FILM MAY BE RELEVANT**

Where the grower has a defined objective such as:

- improving light to interior fruit,
- investigating rind-colour response,
- or comparing shaded and exposed fruit.

### **PUBLISHED TIMING**

**No universal cultivar-specific timing.**

### **WHAT TO MEASURE**

- rind colour,
- Brix,
- acidity,
- maturity,
- fruit weight,
- fruit temperature,
- sunburn,
- external defects,
- pack-out.

## **SOUTH AFRICAN TRIAL REQUIRED**

**YES**

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## **15. MIDKNIGHT VALENCIA**

### **WHAT RESEARCH TELLS US**

There is currently insufficient directly applicable evidence to publish a fixed reflective-ground-film programme for Midnight Valencia.

### **WHERE REFLECTIVE FILM MAY BE RELEVANT**

Potentially where:

- interior canopy light is limited,
- fruit colour is uneven,
- or growers are evaluating reflective light management.

### **PUBLISHED TIMING**

None established for AgriSun.

### **WHAT TO MEASURE**

- colour,
- Brix,
- acidity,
- maturity ratio,
- fruit weight,
- canopy position,
- fruit temperature,
- sunburn,
- pack-out.

## **SOUTH AFRICAN TRIAL REQUIRED**

## **HIGH PRIORITY**

Midnight is commercially relevant enough to justify a properly designed local trial.

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## **16. DELTA VALENCIA**

### **WHAT RESEARCH TELLS US**

The available evidence does not establish a Delta Valencia-specific timing or commercial response.

### **WHERE REFLECTIVE FILM MAY BE RELEVANT**

Potentially where growers want to investigate:

- canopy-light distribution,
- shaded fruit,
- rind colour,
- or fruit-quality response.

### **PUBLISHED TIMING**

**No universal timing established.**

## WHAT TO MEASURE

- rind colour,
- Brix,
- acidity,
- maturity,
- fruit size,
- fruit temperature,
- external quality,
- pack-out.

## SOUTH AFRICAN TRIAL REQUIRED

YES

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## 17. IMPORTANT ORANGE MESSAGE

AgriSun should **not** advertise:

**“Reflective film improves orange colour.”**

as a universal statement.

The correct position is:

**Reflective ground treatment can change the orchard light environment.**

Whether this produces a commercially useful rind-colour or quality response in a particular orange cultivar must be measured locally.

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## 18. LEMONS

Lemons provide particularly useful research because a published Japanese study directly investigated reflective sheet mulch in:

# LEMON

and

# HASSAKU CITRUS.

The researchers examined:

- reflected light,
  - plant water status,
  - fruit weight,
  - soluble solids,
  - citric acid,
  - rind colour,
  - antioxidant activity,
  - and ascorbic acid.
- 

## 19. WHAT THE LEMON / HASSAKU STUDY FOUND

The reflective treatment substantially changed the light environment.

The authors reported reflected illumination around the treated trees corresponding to approximately 20 klx at noon on the south side of the canopy, and the paper indicates that the treated trees received markedly greater reflected light than the controls.

The study therefore provides direct evidence that reflective sheet mulch can meaningfully alter the light reaching citrus trees.

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## 20. WHAT THE STUDY DID NOT FIND

This is one of the most important parts of the research.

At harvest, the researchers reported:

**NO SIGNIFICANT DIFFERENCE IN  
FRUIT WEIGHT.**

**NO SIGNIFICANT DIFFERENCE IN  
SOLUBLE SOLIDS.**

**NO SIGNIFICANT DIFFERENCE IN  
CITRIC ACID CONTENT.**

This is extremely useful for AgriSun because it tells us exactly what **not** to claim.

AgriSun should not advertise reflective ground film in lemons as though it automatically:

- increases Brix,
- increases fruit size,
- reduces acidity,
- or improves all fruit-quality variables.

The research does not support those universal statements.

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## **21. WHAT THE STUDY DID FIND BEYOND LIGHT**

The researchers reported increased rind colour in Hassaku fruit.

They also found:

- increased antioxidant activity in Hassaku flesh,
- and increased ascorbic acid concentration in lemon peel

under the treatment conditions.

The authors concluded that these responses were more consistent with the increased light environment, including UV-B, than with water stress.

## **IMPORTANT**

These results belong to the specific Japanese experiment.

They should not be converted into an AgriSun claim that reflective film will increase vitamin C or antioxidants in all commercial lemons.

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# **22. EUREKA LEMON**

## **WHAT RESEARCH TELLS US**

Direct lemon research demonstrates that reflective sheet mulch can substantially alter the light environment.

However, the Japanese study does not establish an Eureka-specific commercial timing programme.

## **WHERE REFLECTIVE FILM MAY BE RELEVANT**

Possible research questions include:

- does additional reflected light alter rind characteristics?
- does it change fruit temperature?
- does it influence external quality?
- does canopy position affect the response?
- can it be incorporated into a defined light-management programme?

## **PUBLISHED TIMING**

**No universal Eureka timing established.**

## WHAT TO MEASURE

- reflected light,
- rind colour,
- fruit-surface temperature,
- fruit weight,
- Brix,
- citric acid,
- maturity,
- sunburn,
- external quality,
- pack-out.

## SOUTH AFRICAN TRIAL REQUIRED

## HIGH PRIORITY

Because direct lemon evidence exists, Eureka is a strong candidate for local validation.

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## 23. LISBON LEMON

### WHAT RESEARCH TELLS US

The broader lemon research provides a scientific reason to evaluate reflective light management, but it does not establish a Lisbon-specific programme.

### WHERE REFLECTIVE FILM MAY BE RELEVANT

Potentially where:

- canopy shading is substantial,
- growers want to evaluate rind response,
- fruit inside the canopy differs from exterior fruit,
- or reflected-light management is the defined research objective.

## **PUBLISHED TIMING**

**No universal Lisbon timing established.**

## **WHAT TO MEASURE**

- canopy/reflected light,
- rind colour,
- fruit temperature,
- weight,
- Brix,
- acidity,
- maturity,
- sunburn,
- external defects,
- pack-out.

## **SOUTH AFRICAN TRIAL REQUIRED**

# **YES**

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## **24. WHY THE LEMON RESEARCH IS SO VALUABLE**

The Japanese study demonstrates an important AgriSun principle:

**MORE LIGHT DOES NOT AUTOMATICALLY  
MEAN EVERY FRUIT-QUALITY VARIABLE  
IMPROVES.**

The treatment substantially altered the light environment.

Yet:

**fruit weight did not significantly change**

**soluble solids did not significantly change**

**citric acid did not significantly change.**

That is credible, useful science.

It allows AgriSun to focus on the physical function of the product and measure individual crop responses rather than making broad promises.

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## 25. QUICK CITRUS SUMMARY

| Citrus            | What current evidence allows AgriSun to say                                                                             |
|-------------------|-------------------------------------------------------------------------------------------------------------------------|
|                   | Reflective white mulch increased reflected light and                                                                    |
| <b>Clemenpons</b> | changed soil-temperature conditions; major treatment                                                                    |
| <b>Clementine</b> | differences occurred around <b>70–30 days before harvest</b> ,<br>but this is <b>not an installation recommendation</b> |
| <b>Nadorcott</b>  | Cultivar-specific South African timing trial required                                                                   |
| <b>Tango</b>      | Cultivar-specific South African timing trial required                                                                   |
| <b>Nova</b>       | Cultivar-specific South African timing trial required                                                                   |
| <b>Navel</b>      | Cultivar- and objective-specific South African trial<br>required                                                        |
| <b>Valencia</b>   | Cultivar- and objective-specific South African trial<br>required                                                        |
| <b>Midknight</b>  | Cultivar- and objective-specific South African trial<br>required                                                        |
| <b>Delta</b>      | Cultivar- and objective-specific South African trial                                                                    |
| <b>Valencia</b>   | required                                                                                                                |
| <b>Eureka</b>     | Direct lemon reflective-mulch research supports                                                                         |
| <b>lemon</b>      | evaluation, but no Eureka-specific timing established                                                                   |
| <b>Lisbon</b>     |                                                                                                                         |
| <b>lemon</b>      | Local cultivar-specific trial required                                                                                  |

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# 26. SOUTH AFRICAN CITRUS

## TRIAL PRIORITIES

### PRIORITY 1 — NADORCOTT

Main questions:

**Does reflected orchard-floor light influence rind colour under South African conditions?**

**What deployment period is appropriate?**

Measure:

- rind colour,
- Brix,
- acidity,
- maturity,
- fruit temperature,
- sunburn,
- pack-out.

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### PRIORITY 2 — CLEMENTINE

Validate whether the light and soil-temperature relationships observed in Clemenpons occur under South African production conditions.

Measure:

- reflected light,
  - soil temperature,
  - rind colour,
  - fruit temperature,
  - maturity,
  - pack-out.
-

## **PRIORITY 3 — EUREKA LEMON**

Use the Japanese lemon research as the scientific starting point.

Measure:

- reflected light,
  - rind characteristics,
  - fruit temperature,
  - weight,
  - Brix,
  - citric acid,
  - sunburn,
  - external quality.
- 

## **PRIORITY 4 — MIDKNIGHT / VALENCIA / DELTA**

Determine whether changing the orchard light environment produces a commercially relevant response.

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## **PRIORITY 5 — TANGO / NOVA**

Develop cultivar-specific timing and response data.

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## **PRIORITY 6 — LISBON LEMON**

Validate the broader lemon findings locally.

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# **27. HOW TO SET UP A SOUTH AFRICAN CITRUS TRIAL**

## TREATED AREA

AgriSun Reflective Orchard Film.

## CONTROL AREA

Comparable trees under the grower's normal orchard management without reflective ground film.

Where testing timing:

### TREATMENT A

Earlier deployment.

### TREATMENT B

Later deployment.

### CONTROL

No reflective film.

Do **not** label either treatment as the correct timing before the data are available.

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# 28. CORE CITRUS MEASUREMENTS

## LIGHT

Where equipment is available:

- reflected radiation,
- PAR,
- canopy position.

## COLOUR

- rind colour,
- colour uniformity,
- treated vs control.

## SOLUBLE SOLIDS

°Brix / TSS

## ACIDITY

Record:

- titratable acidity,
- or citric acid depending on the trial.

## MATURITY

Use the grower's normal cultivar-specific maturity criteria.

## FRUIT SIZE

Measure:

- weight,
- diameter,
- commercial class.

## TEMPERATURE

Where practical:

- fruit-surface temperature,
- soil temperature,
- ambient conditions.

## SUNBURN

Record:

- incidence,

- severity,
- fruit position.

## EXTERNAL QUALITY

Record:

- rind defects,
- blemishes,
- damage,
- commercial grade.

## PACK-OUT

Where possible, compare treated and control fruit by normal commercial grading.

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# 29. IMPORTANT CITRUS

## INTERPRETATION RULE

**CHANGING LIGHT  $\neq$  GUARANTEED BRIX  $\neq$   
GUARANTEED SIZE  $\neq$  GUARANTEED  
COLOUR.**

The lemon/Hassaku study is a particularly good example.

The treatment clearly altered the light environment, yet fruit weight, soluble solids and citric acid were not significantly different at harvest.

Each commercial response must therefore be measured independently.

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## 30. WHAT AGRISUN SHOULD NOT CLAIM

AgriSun should not currently claim that reflective orchard film universally:

- increases citrus Brix,
- increases fruit weight,
- lowers acidity,
- improves rind colour in every cultivar,
- accelerates maturity,
- prevents sunburn,
- increases yield,
- improves pack-out,
- increases vitamin C,
- increases antioxidant activity,
- or produces a guaranteed financial return.

Individual studies have reported some of these responses under specific experimental conditions.

Those findings must remain attributed to the relevant research.

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## 31. SCIENTIFIC REFERENCES

### CLEMENPONS CLEMENTINE

Mesejo, C., Gambetta, G., Gravina, A., Martínez-Fuentes, A., Reig, C. & Agustí, M. (2012).

**Relationship Between Soil Temperature and Fruit Colour Development of ‘Clemenpons’ Clementine Mandarin (*Citrus clementina* Hort. ex Tan.).**

*Journal of the Science of Food and Agriculture*, 92(3), 520–525.

DOI: [10.1002/jsfa.4600](https://doi.org/10.1002/jsfa.4600).

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### LEMON & HASSAKU

Akasaka, S., Ikeda, H., Watanabe, Y. & Kohmura, H. (2008).

**Effects of Reflective Sheet Mulch on Antioxidant Activity, Ascorbic Acid Levels and Fruit Quality in Lemon and Hassaku Fruit.**

*Bulletin of the Hiroshima Prefectural Technology Research Institute Agricultural Technology Research Center*, 83, 11–16.

DOI: [10.82682/hitriatrc.83.0\\_11](https://doi.org/10.82682/hitriatrc.83.0_11).

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## 32. IMPORTANT USE NOTICE

The citrus research described in this guide involved particular cultivars, reflective materials, climates and experimental objectives.

The Clemenpons study does **not** establish a universal 70-day installation programme.

The lemon/Hassaku study does **not** establish an Eureka or Lisbon application timing.

Nadorcott, Tango, Nova, Navel, Valencia, Midnight, Delta Valencia, Eureka and Lisbon therefore require cultivar-specific South African validation before AgriSun develops fixed commercial application timings.

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## AGRISUN REFLECTIVE SOLUTIONS

### Better Light. Applied With Evidence.

**Published research tells us what is possible to investigate.**

**South African trials tell us what is commercially useful in our cultivars and our orchards.**