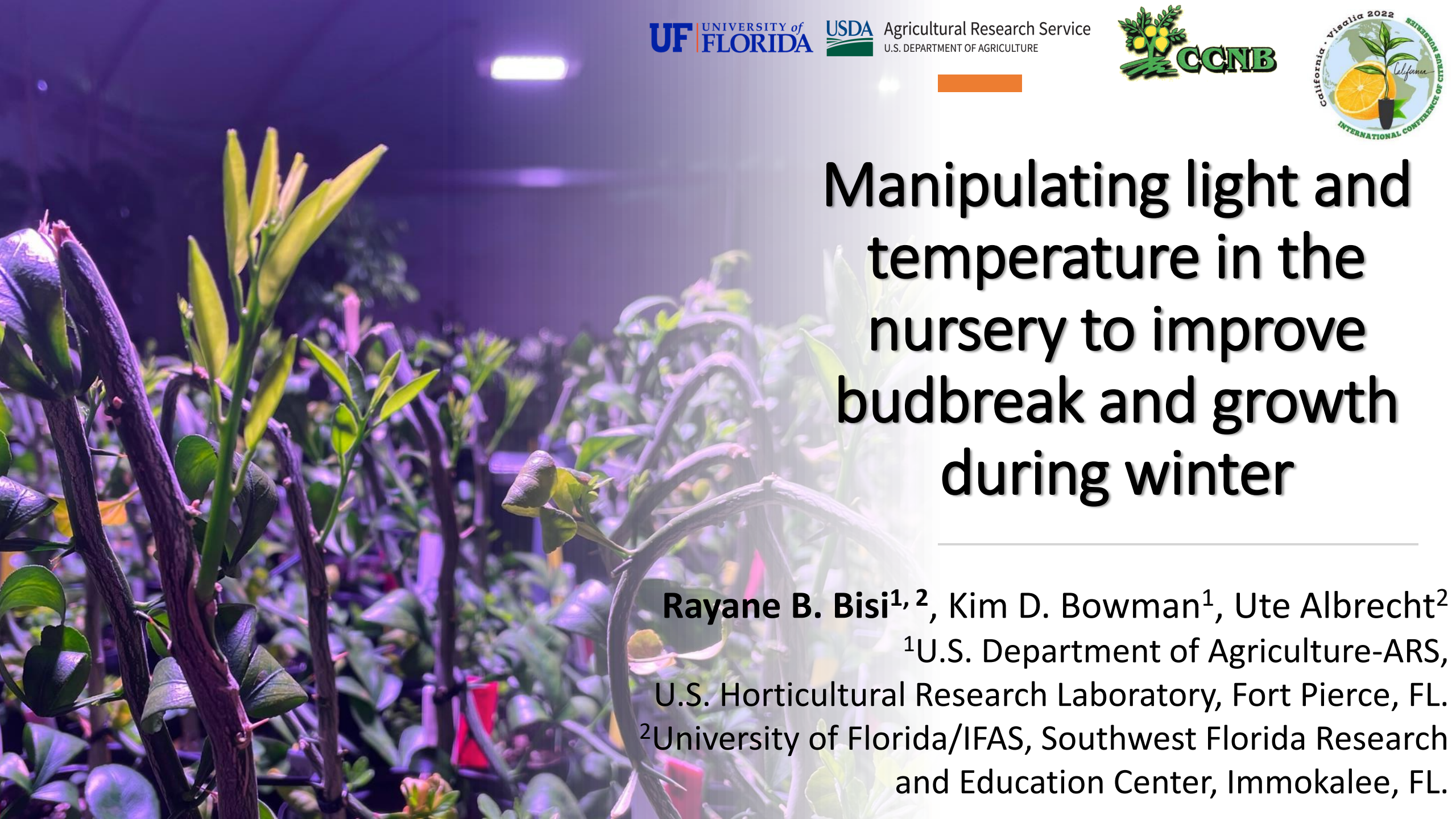


Manipulating light and temperature in the nursery to improve budbreak and growth during winter

Rayane B. Bisi[1, 2], Kim D. Bowman[1], Ute Albrecht[2]

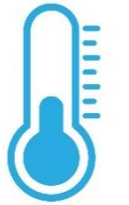
[1]U.S. Department of Agriculture-ARS, U.S. Horticultural Research Laboratory, Fort Pierce, FL.

[2]University of Florida/IFAS, Southwest Florida Research and Education Center, Immokalee, FL.

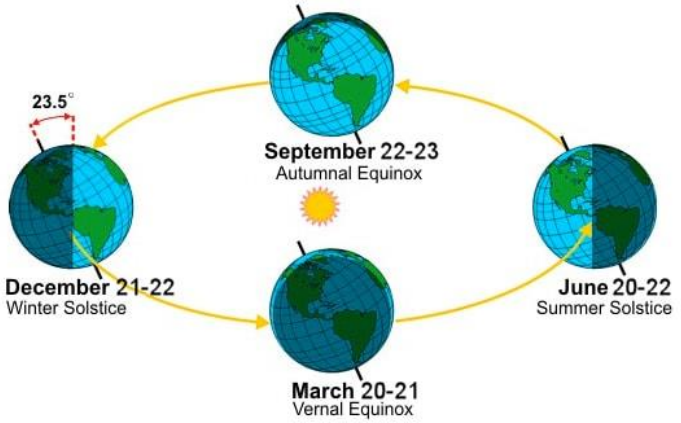
Introduction

During the winter, the citrus nursery production cycle is considerably slowed.

Citrus nurseries stop or reduce budding of new trees due to:

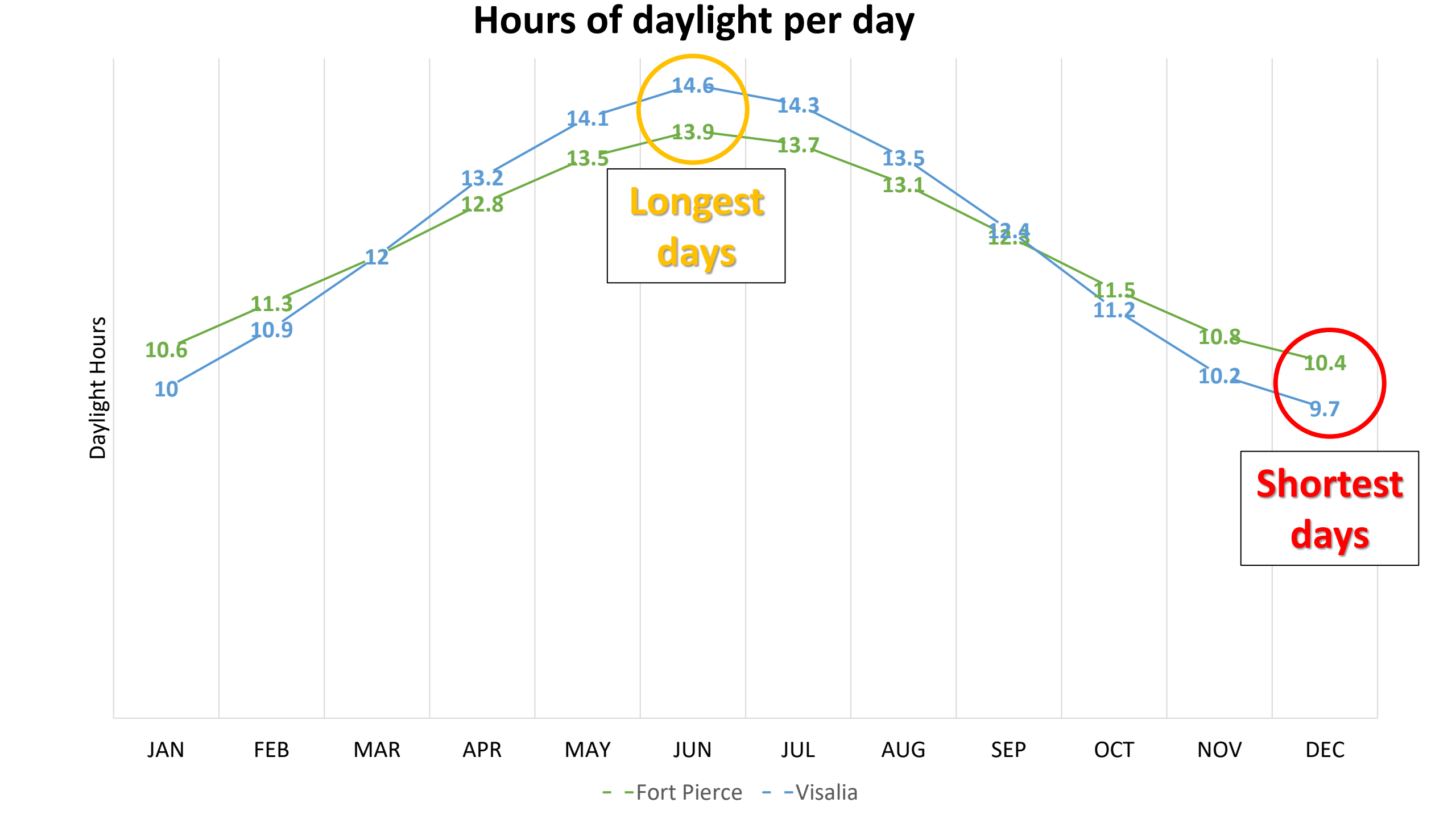


Low temperature



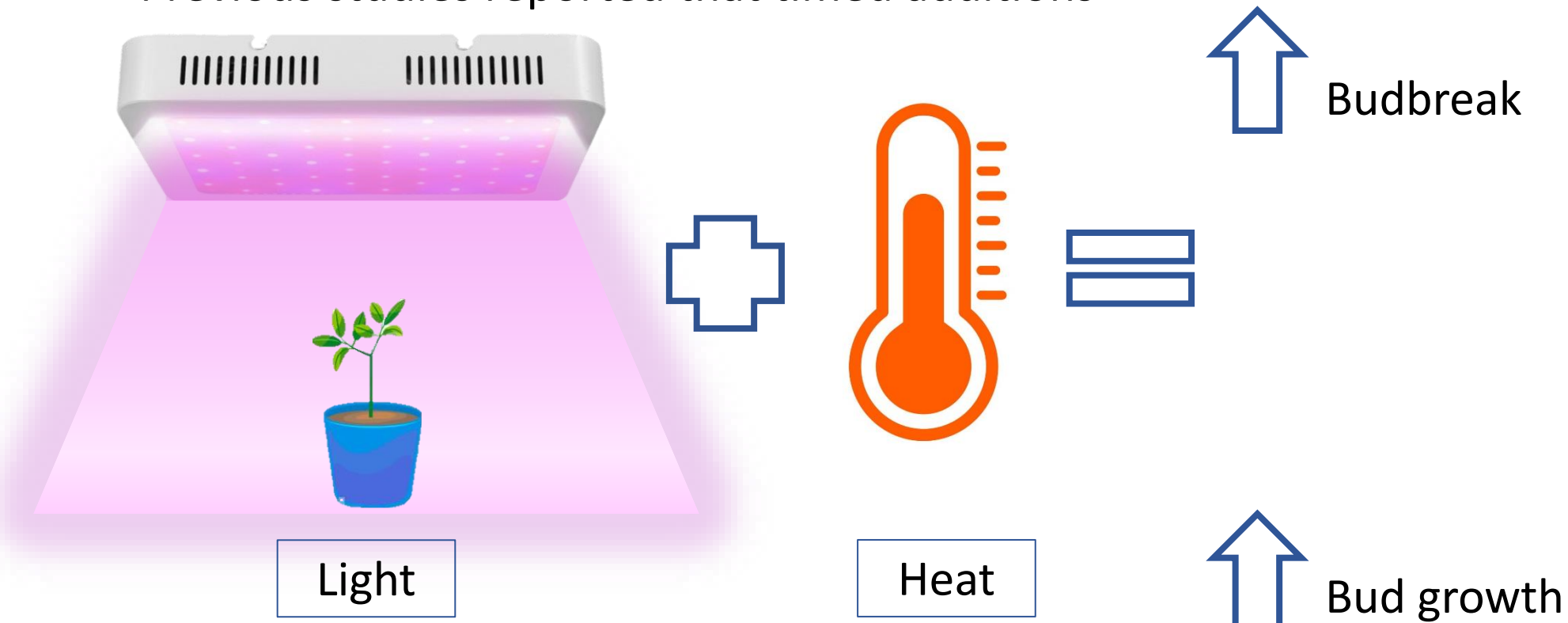
Short-day

Cause: ⇩ Reduction of **budbreak** and **bud growth**


Hours of daylight per day
Daylight Hours
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
10.6
11.3
12
12.8
13.5
13.9
13.7
13.1
12.3
11.5
10.8
10.4
10
10.9
12
13.2
14.1
14.6
14.3
13.5
12.4
11.2
10.2
9.7
Longest days
Shortest days
Fort Pierce
Visalia

Introduction

- Previous studies reported that timed additions



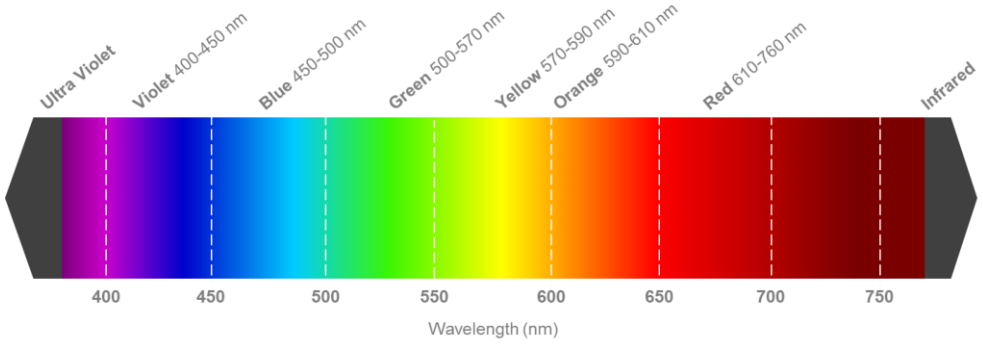
- Little information is available about the **optimum** combination of **light** and **temperature** in the citrus nursery.

Several physiological and developmental events in plants are controlled by light.

Plants respond to two aspects of light

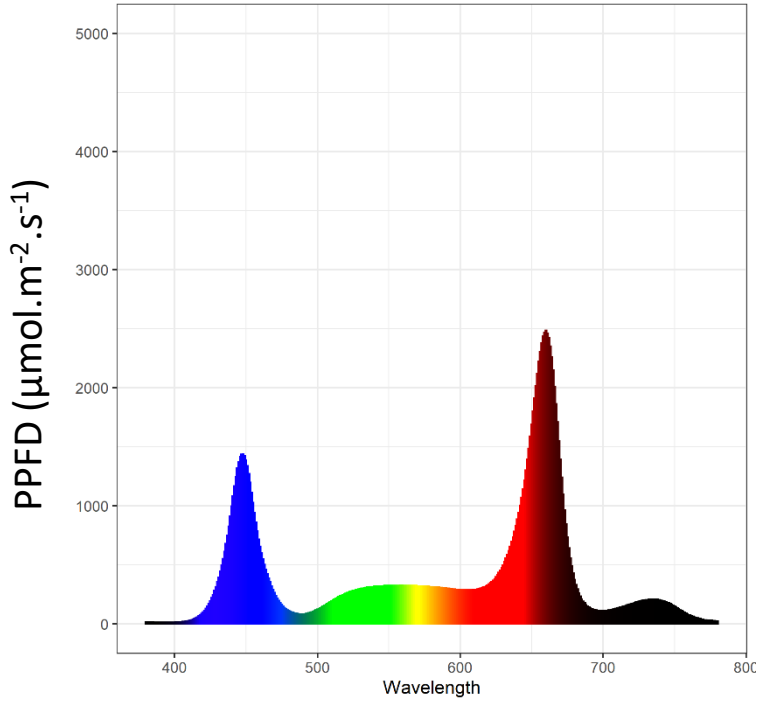
Quality

- Spectrum



Quantity

- Intensity
- Duration of exposure



HortScience 56(1):21 27. 2021. https://doi.org/10.21273/HORTSCI15302-20

Improving Winter Growth in the Citrus Nursery with LED and HPS Supplemental Lighting

Kim D. Bowman
U.S. Horticultural Research Laboratory, Agricultural Research Service, U.S. Department of Agriculture, Ft. Pierce, FL 34945

Ute Albrecht
Southwest Florida Research and Education Center, Horticultural Sciences Department, Institute of Food and Agricultural Sciences, University of Florida, Immokalee, FL 34142

Additional index words. Cleopatra, cutting, day length, micropropagation, nursery, photoperiod, rootstock, seedling, sour orange, sweet orange, 'US-1516', 'US-812', 'US-897', 'US-942'

Abstract. **Modern citrus nursery production makes use of potted-tree propagation in greenhouses. Supplemental lighting is one method by which nursery tree growth and profitability may be significantly improved, but limited specific information is available. Five replicated experiments were conducted to determine the utility and effects of increasing daylength during the winter months by supplemental illumination from light-emitting diode (LED) or high-pressure sodium (HPS) lights in citrus nursery propagation. Studies used 'Valencia' sweet orange scion, the most common citrus cultivar grown in Florida, and the commercially important rootstocks sour orange, 'Cleopatra' mandarin, 'US-812', 'US-897', 'US-942', and 'US-1516'. Comparisons used the three common types of citrus rootstock propagation: seed, stem cuttings, and micropropagation. Six responses were measured in the lighting experiments, including vegetative growth before budding, scion bud survival, and scion bud growth after budding. Supplemental HPS or LED light to extend daylength to 16 h in the citrus nursery during short-day winter months was observed to be effective in increasing unbudded rootstock liner growth and 'Valencia' scion growth on all rootstocks and propagation types. Generally, the positive effect on vegetative growth from an increased daylength was stronger with the HPS light than with LED light, while increasing daylength with LED light, but not HPS light, provided some increased bud growth initiation. Use of HPS or LED supplemental lighting to extend daylength offers significant growth advantage for the citrus nursery industry in winter.**

light to increase daylength. Tree growth was increased 339% when the daylength increase used higher intensity lighting that combined incandescent and fluorescent sources. It was suggested that this indicated both a photoperiod-sensitive and a photosynthetic response. Growth of sweet orange (*C. sinensis* L. Osbeck) on 'Troyer' rootstock (*C. sinensis* × *P. trifoliata*) trees was also reported to be increased by extending daylength with incandescent light during the winter (Nauer et al., 1979). Long- and short-day effects were studied on several rootstock selections as seedlings and in graft combination with citrus scions, and results were interpreted as indicating that some rootstocks exhibited a strong positive growth response to long-day treatments, whereas other rootstocks did not (Warner et al., 1979). For 'Satsuma' mandarin (*C. reticulata* L. Blanco) on *P. trifoliata* rootstock, both shoot length and shoot fresh weight were significantly larger when plants were grown under 16-h daylength than when plants were grown under 8-h daylength (Inoue, 1989). Research conducted in growth chambers indicated that vegetative growth of two trifoliate hybrid rootstocks may be increased in small potted citrus plants by either long daylength or the use of light to interrupt the dark period during short day periods, suggesting a phytochrome-mediated response (Brar and Spann, 2014). There is evidence that supplemental light increases growth of citrus nursery trees during short days, but there is not clear quantitative information on the amount and nature of the growth improvement among current citrus rootstock types under modern greenhouse conditions and in response to the use of modern supplemental HPS or LED lights.

Supplemental light has been studied in many plant systems and has been shown to typically have large effects to improve or

Objective: Evaluate the effect of supplemental LED light and heat on the budbreak and bud growth during the winter short days.

1st Year

Light

How much hours of light is needed?

- 16 hours daylength
- Night Interruption
- Is light preconditioning needed?

Temperature

How much supplemental heat is needed?

W. Navel
(*Citrus sinensis*)

Scion

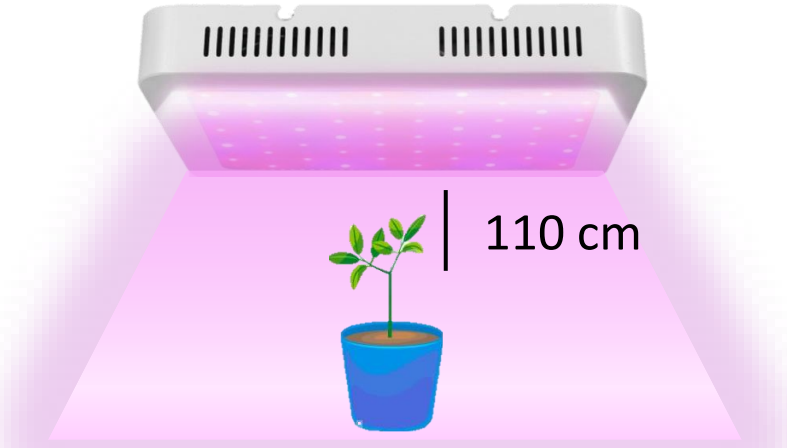
Carrizo
(*C. sinensis* × *P. trifoliata*)

Rubidoux
(*P. trifoliata*)

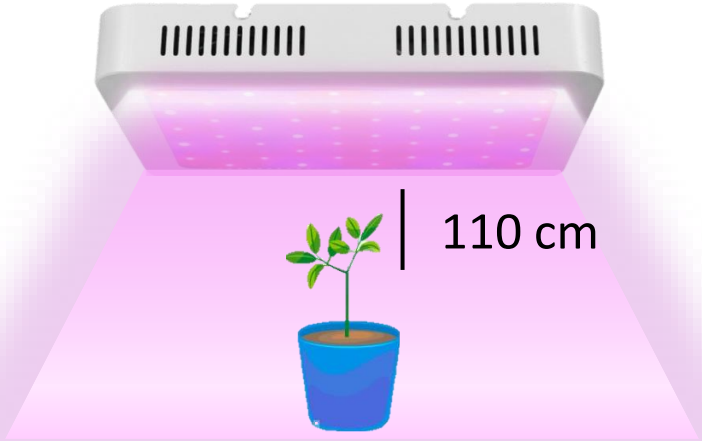
Rootstock

Light treatments:

No supplemental light



Daylength extension to 16 h



Night interruption

Preconditioning

Light treatment 6 weeks before budding

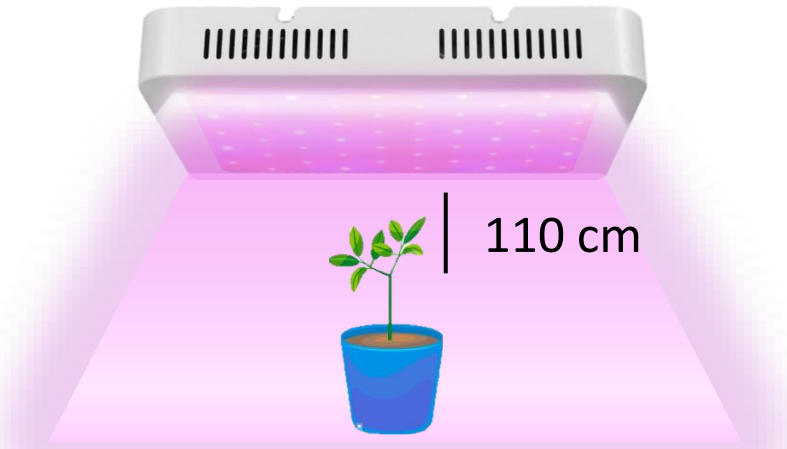
No Preconditioning

Light treatment on the bud day

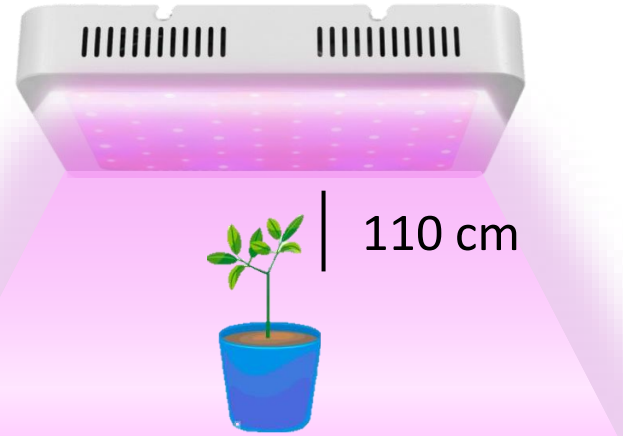
5 Light treatments:

No supplemental light

Preconditioning

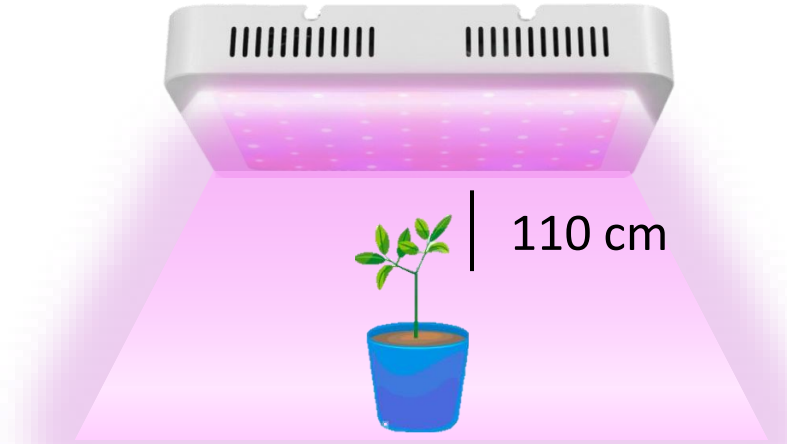


Daylength extension to 16 h

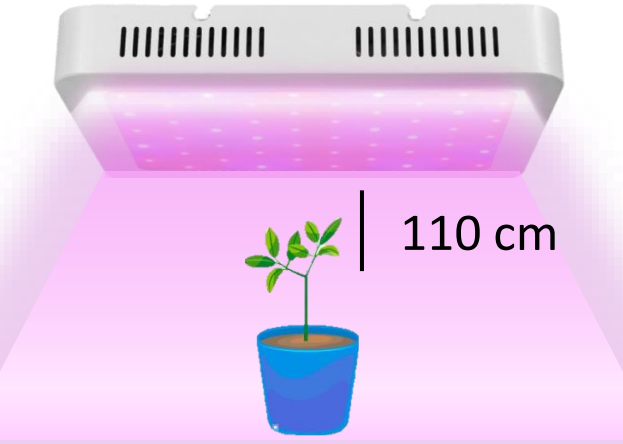


Night interruption

No Preconditioning



Daylength extension to 16 h



Night interruption

Light treatments

Temperature treatments

Set:

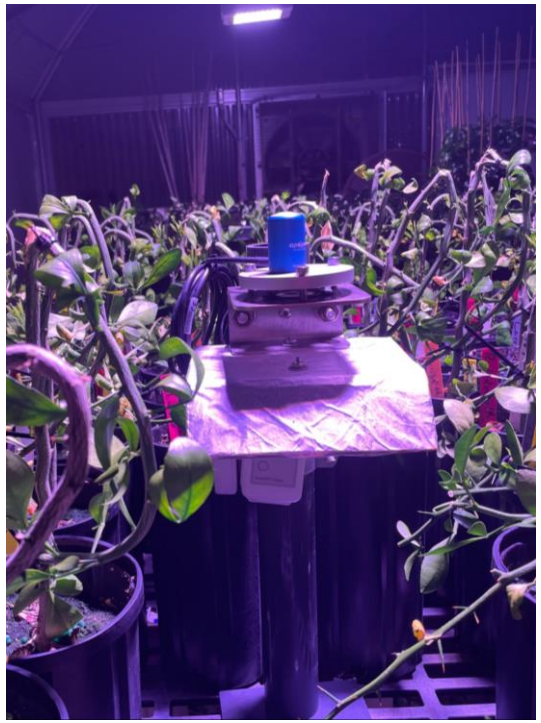
26 – 32 °C	21 – 27 °C	≥ 22 °C

Temperature (Min – Max):

27 – 35 °C	22 – 30 °C	16 – 30 °C

Heliospectra LED Light

PG100N Spectrometer



SQ-500-SS

MX2203

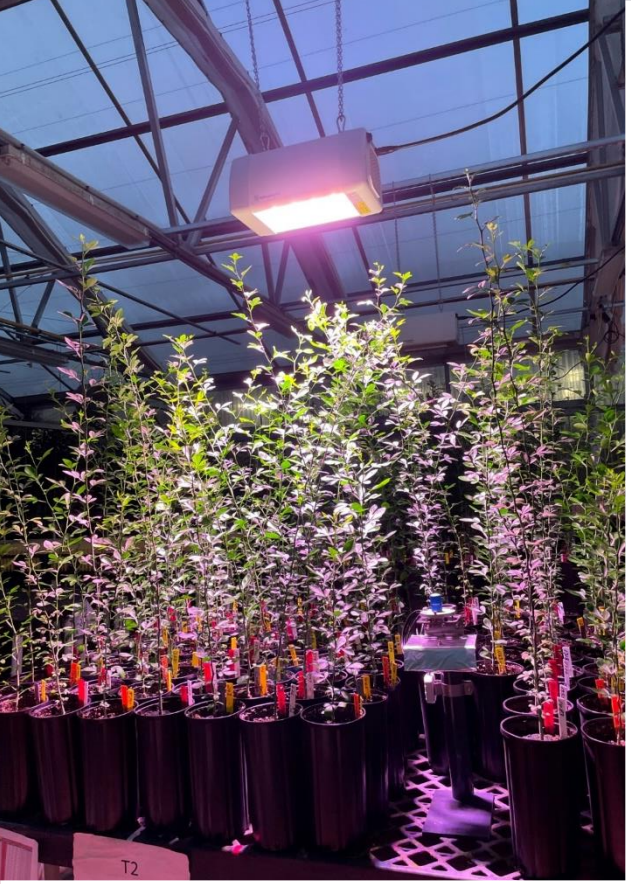
- Light at full intensity
- Light spectrum and intensity
- Daily light integral (DLI)
- Air temperature

Photosynthetic Photon Flux Density(PPFD):364.4 $\mu mol.m^{-2}.s^{-1}$

Photon Flux Density-Blue (PFD): 68.0 $\mu mol.m^{-2}.s^{-1}$

PFD-Red: 232.8 $\mu mol.m^{-2}.s^{-1}$

PFD-Far Red: 31.2 $\mu mol.m^{-2}.s^{-1}$





- 5 Light treatments
- 3 Temperature treatments
- 4 Replications
- 24 plants per replication

  1440 W. Navel on Carrizo rootstock

  1440 W. Navel on Rubidoux rootstock

Plants were scored periodically for:

- Budbreak
- Scion shoot length

Assessment: 4, 6, 8, 10 and 12 Weeks After Budding (WAB)

- Scion diameter

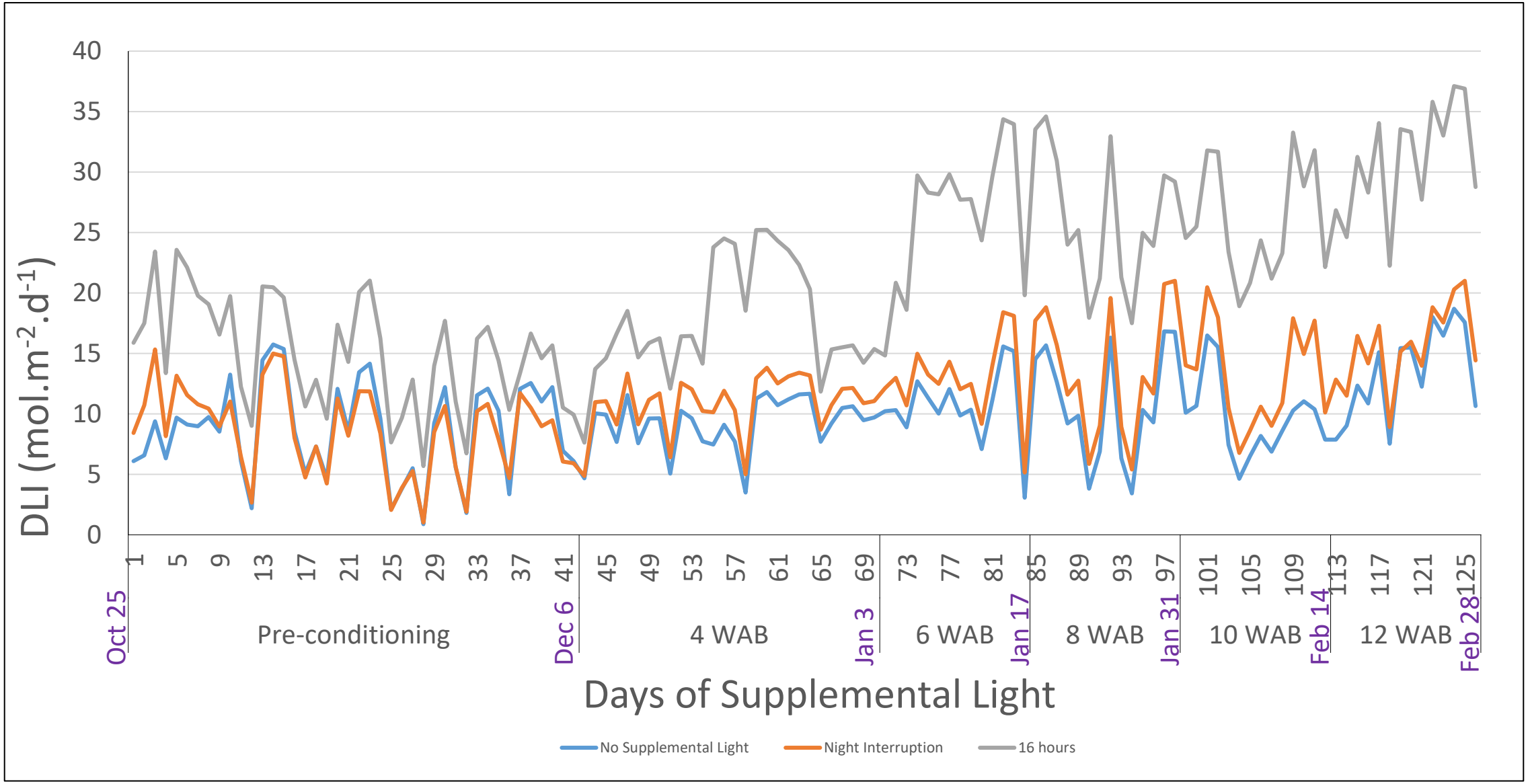


Fig 1. Daily light integral (DLI) from no supplemental light, night interruption and day length extension to 16 hours from Pre-conditioning to 12 weeks after budding (WAB).

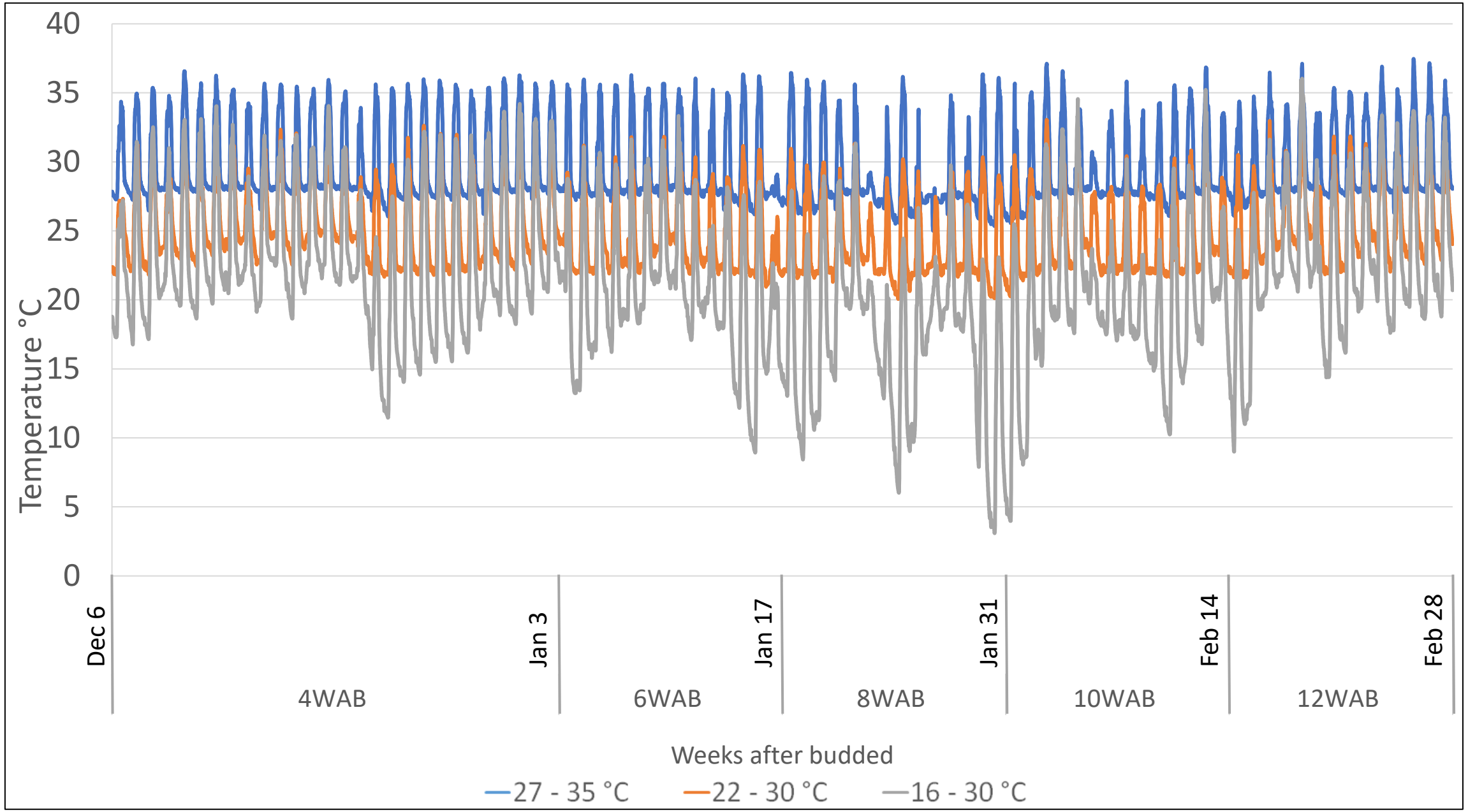
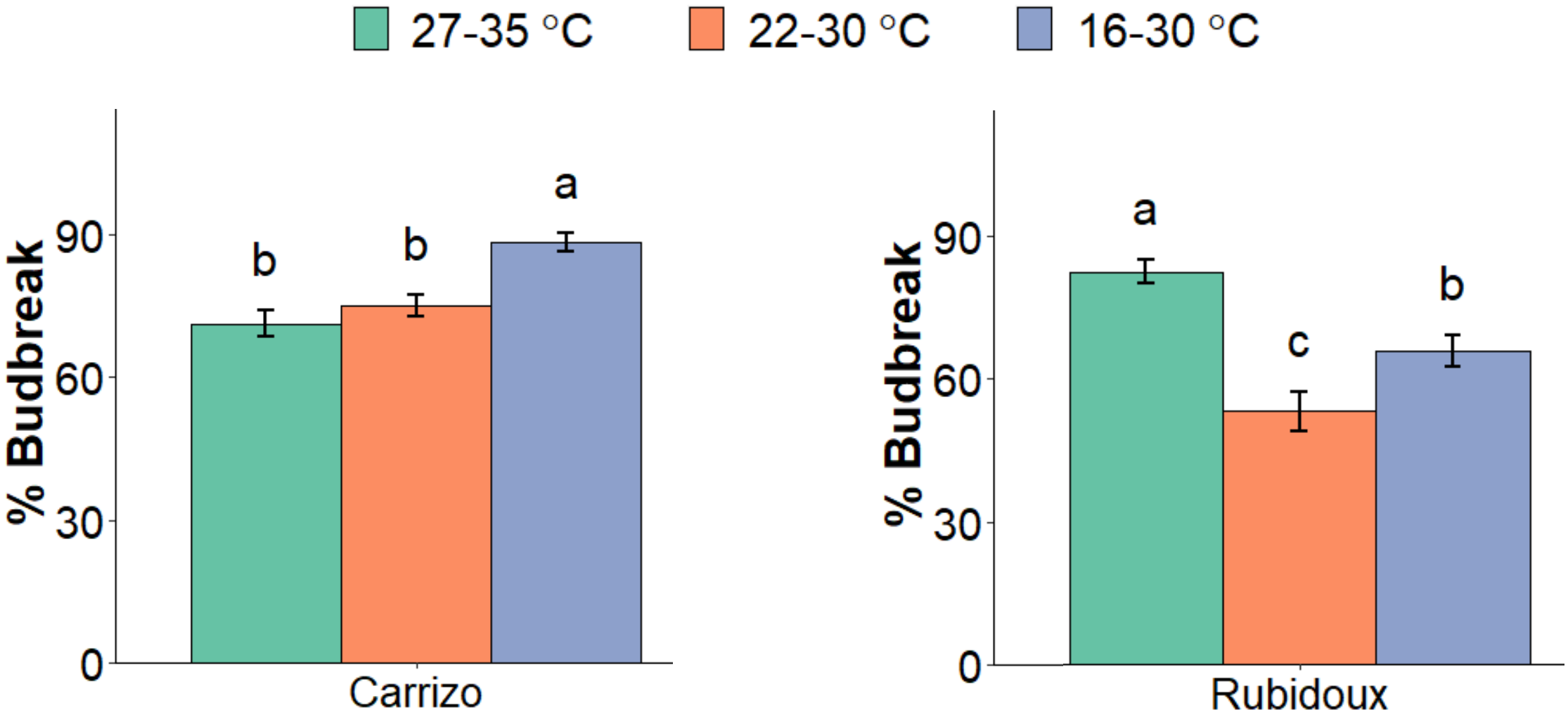


Fig 2. Daily temperature from budding to 12 weeks after budding.

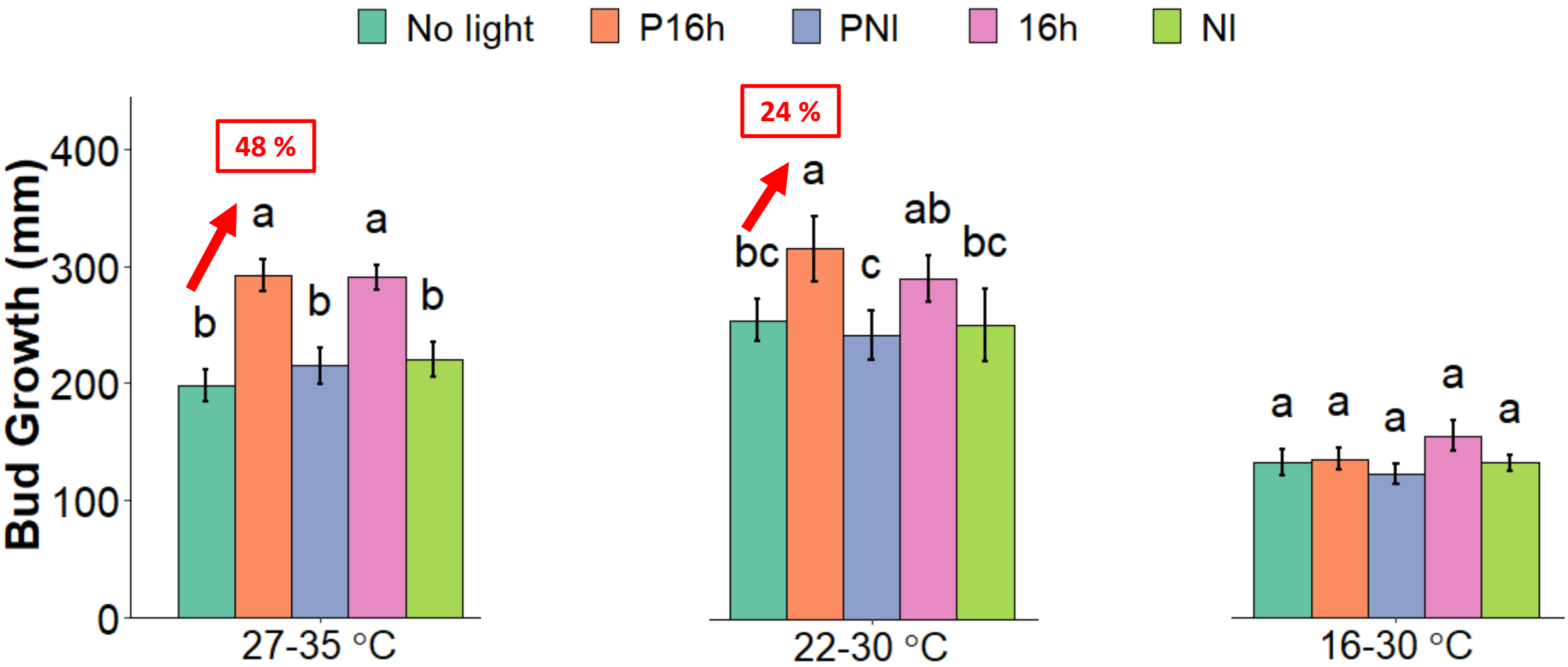
Results

The supplemental LED light at full spectrum did not affect the percentage of budbreak significantly.

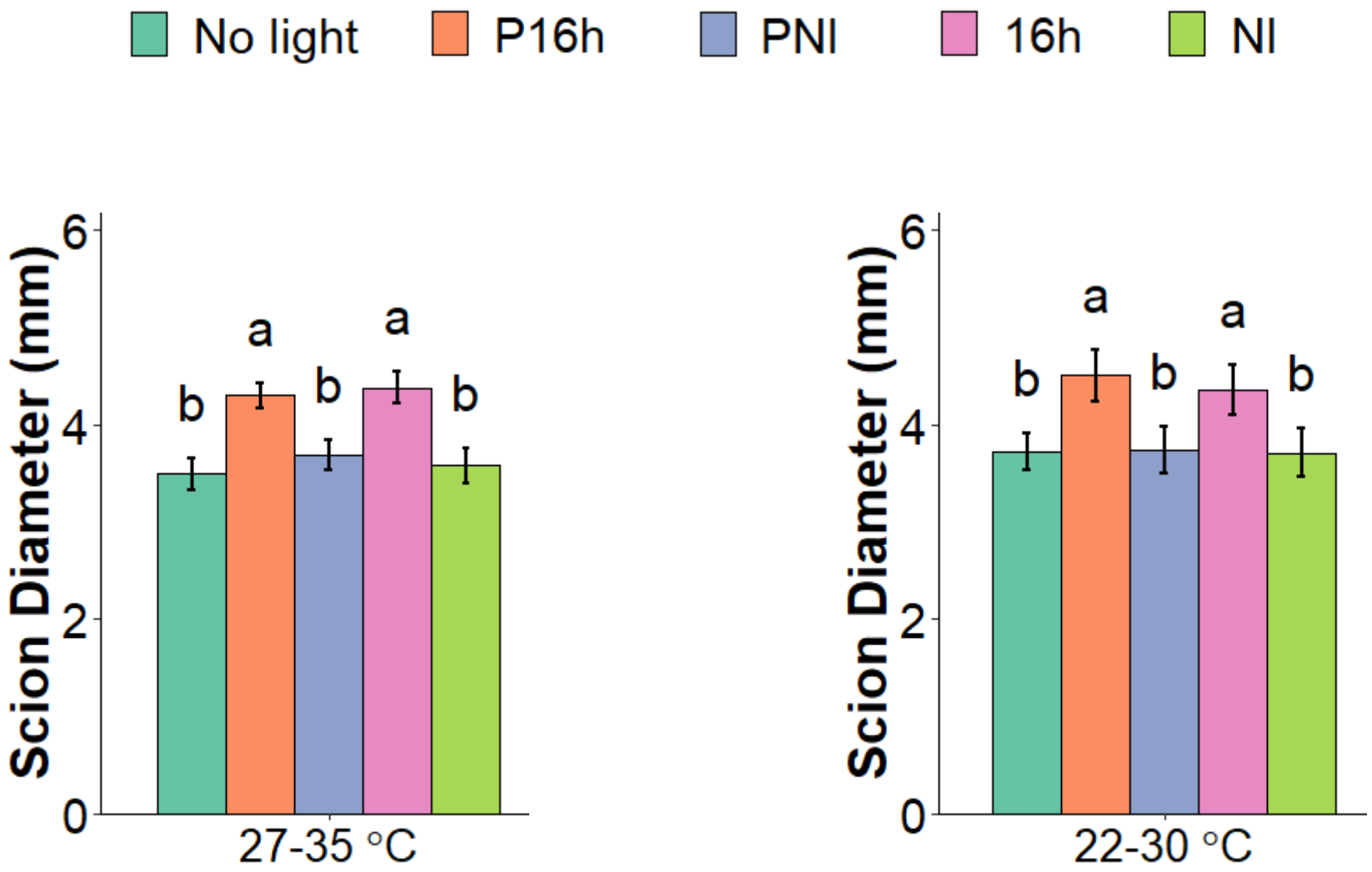
Percentage of budbreak at 12 WAB



Bud growth of W. Navel at 12 WAB



Scion diameter of W. Navel



Washington Navel on Carrizo and Rubidoux rootstock under daylength extension to 16 hours

27 – 35 °C

22 – 30 °C

Conclusions

- In this study the supplemental LED light at full intensity does not affect budbreak.
- Daylength extension to 16 hours and temperature combined increase scion bud growth.
- Supplemental LED light does not affect bud growth in low temperatures.
- Daylength extension to 16 hours increase scion bud growth on Carrizo and Rubidoux.
- Night interruption did not affect bud growth.
- Preconditioning light treatment has a positive effect on the bud growth.

Further considerations

1st Year

Light

How much light timing is needed?

- 16 hours daylength ✓
- Night Interruption
- Is light preconditioning needed?

Temperature

How much supplemental heat is needed?

Set: 21 – 27 °C

Average: 22 – 30 °C

Objective: Evaluate budbreak and growth effects from spectral quality and intensity in the winter citrus nursery

2nd Year

Light

- What is the best Light Spectrum?

  Combinations:
  - ➡ Blue (450 nm)
  - ➡ Red (660 nm)
  - ➡ Far-red (735 nm)
  - ⇨ White (5700K)

- What is the best Light Intensity?

  Different intensities

Temperature

- **Set temperature at 21 – 27 °C**

Acknowledgements

Dr. Kim D. Bowman
USDA - ARS

Dr. Ute Albrecht
University of Florida
IFAS SWFREC

Sponsors

CCNB

USDA Agricultural Research Service
U.S. DEPARTMENT OF AGRICULTURE

UF IFAS
UNIVERSITY of FLORIDA

Thank you

Rayane B. Bisi, Ph.D.
Postdoctoral Research Associate
rbarcelosbisi@ufl.edu
rayane.bisi@usda.gov

University of Florida
United States Department of Agriculture
Agricultural Research Service
US Horticultural Research Laboratory
2001 South Rock Road | Fort Pierce, FL 34945
Phone: 772-462-5941 | Cell: 772-979-1838

UF IFAS
UNIVERSITY of FLORIDA

USDA Agricultural Research Service
U.S. DEPARTMENT OF AGRICULTURE