Approved Budget Line Item:	**510**	Contract No.
Board Recommendation Date:	**12/15/22**	**BOW-23**

STANDARD AGREEMENT

This Agreement is made and entered into this 1st Day of (month) January (year) 2023 , in the State of California, by and between the Board, through its duly elected or appointed, qualified and acting

Name of Board

CALIFORNIA CITRUS NURSERY BOARD , hereinafter called the Board, and

Contractor's Name

USDA-ARS, Fort Pierce, Florida , hereinafter called the Contractor.

WITNESSTH: That the Contractor for and in consideration of the covenants, conditions, agreements, and stipulations of the Board hereinafter expressed, does hereby agree to furnish to the Board services and materials as follows: (*Set forth service to be rendered by Contractor, amount to be paid Contractor, time for performance or completion, and attach plans and specifications, if any.)* The provisions on the reverse side hereof constitute a part of this agreement.

Contract Title: "Manipulating Light and Temperature in the Nursery to Improve Budbreak and Growth during Winter"

Project Leader: Kim D. Bowman, USDA-ARS, Fort Pierce, Florida

Contract Amount: **$13,334** (*USDA-ARS portion of total project amount of $93,772*)

Contract Period: January 1, 2023 through December 31, 2023

CONTINUED ON _____ SHEETS

IN WITNESS WHEREOF, this agreement has been executed by the parties hereto, upon the date first above written.

BOARD	CONTRACTOR	
Board Name **California Citrus Nursery Board**	Contractor (If not an individual, state whether a corporation, partnership, etc.) **USDA-ARS, Fort Pierce, Florida**	
By (Authorized Signature) Don Dillon Don Dillon (Jan 18, 2023 15:07 PST)	By (Authorized Signature)	
Printed Name of Person Signing **Don Dillon - Chairman**	Printed Name and Title of Person Signing **Jan Moreno, Grants Management Specialist**	
Title **John Gilstrap, Board Manager**	Address	

1. It is understood and agreed that neither party to this Agreement shall be responsible for any damages or injuries arising out of the conduct of activities governed by this Agreement, except to the extent that such damages and/or injuries were caused by the negligent or wrongful acts or omissions of its employees, agents or officers. ARS' liability shall be limited by the Federal Tort Claims Act, 28U.S.C. 2671, et seq.

2. The Contractor, and the agents and employees of Contractor, in the performance of this agreement, shall act in an independent capacity and not as officers or employees or agents of the Board.

3. The Board and Contractor may terminate this agreement and be relieved of the payment of any consideration to Contractor should Contractor fail to perform the covenants herein contained at the time and in the manner herein provided. In the event of such termination the Board may proceed with the work in any manner deemed proper by the Board. The cost to the Board shall be deducted from any sum due the Contractor under this agreement, and the balance, if any, shall be paid to Contractor upon demand.

4. Without written consent of the Board, this agreement is not assignable by Contractor either in whole or in part.

5. No alteration or variation of the terms of this contact shall be valid unless made in writing and signed by the parties hereto, and no oral understanding or agreement not incorporated herein, shall be binding on any of the parties hereto.

6. The consideration to be paid Contractor, as provided herein, shall be in compensation for all of Contractor's expenses incurred in the performance hereof, including travel and per diem, unless otherwise expressly so provided.

7. During the performance of this contract, Contractor and its subcontractors shall not unlawfully discriminate against any employee or applicant for employment because of race, religion, color, national origin, ancestry, physical handicap, medical condition, marital status, age (over 40), or sex. Contractors and subcontractors shall insure that the evaluation and treatment of their employees and applicants for employment are free of such discrimination. Contractors and subcontractors shall comply with the provisions of the Fair Employment and Housing Act (Government Code Section 12900 et seq.) and the applicable regulations promulgated thereunder (California Code of Regulations Title 2, Section 7285.0 et seq.). The applicable regulations of the Fair Employment and Housing Commission implementing Government Code Section 12990, set forth in Chapter 5 of Division 4 of Title 2 of the California Code of Regulations are incorporated into this contract by reference and made a part hereof as if set forth in full. Contractor and its subcontractors shall give written notice of their obligations under this clause to labor organizations with which they have a collective bargaining or other agreement. This Clause shall apply only to the extent that the requirements therein are otherwise applicable to the Federal Government.

This Contractor shall include the nondiscrimination and compliance provisions of this clause in all subcontracts to perform work under the contract.

8. Failure to Comply - "It is hereby mutually agreed that by signing this agreement, Contractor does swear under penalty of perjury, that no more than one (1) final unappealable finding of contempt of court by a Federal court has been issued against Contractor within the immediately preceding two-year period because of the Contractor's failure to comply with an order of a Federal court which orders the Contractor to comply with an order of the National Labor Relations Board (Public Contract Code Section 10296)."

9. It is mutually agreed that the Contractor shall be subject to examination and audit of the State of California for a period of three years after final payment under this agreement (Government Code Section 10532). The examination and audit shall be confined to those matters connected with the performance of this contract including but not limited to the cost of administering the contract.

10. It is mutually agreed that if the Board's budget authority is repealed by the Legislature in the current year and/or any subsequent years covered under this agreement, this contract shall be of no further force and effect. In this event, the Board shall have no liability to pay any funds whatsoever to the Contractor or to furnish any other considerations under this contract and the Contractor shall not be obligated to perform any provisions of this contract.

11. This contract shall not be considered effective until signed by both parties.

1. Contractor agrees to perform research in accordance with proposal entitled **"Manipulating Light and Temperature in the Nursery to Improve Budbreak and Growth during Winter"**, a copy of which is marked Exhibit "A" attached hereto and made a part hereof, to be conducted by **Kim D. Bowman, USDA-ARS, Fort Pierce, Florida,** said research to cover the period **January 1, 2023** through **December 31, 2023**.

2. The Board shall pay the Contractor a total of **$13,334** for the work herein described (*This is the USDA-ARS portion of the full amount of the project, $93,772*). The Contractor shall submit an invoice in the full amount of the contract and the Board shall have the option of making payment in full or in three installments, the first of which will be for 50% and paid upon final execution of this contract, the second of which will be 40% and paid no later than **October 1, 2023**, and the last of which will be for the final 10%, paid within 15 days of the Board's receipt of the final report.

3. If due to factors beyond the control of the Board, funds are not available to the Board for payment to Contractor pursuant to Paragraph 2 of this agreement, Contractor agrees to reduce expenditures for research described in Exhibit "A". Board agrees to provide Contractor the earliest possible written notice of the lack of available funds. In the event of such a cancellation, Board agrees to pay Contractor for all costs incurred to the effective date of cancellation including all uncancelable obligations made in connection with the performance of this agreement.

4. If the Contractor finds that as of **December 31, 2023** there are any unexpended balances of the aforesaid funds, said balances shall be shown as carryover funds if this project is to be continued. If the project is completed, excess funds shall be transferred to another project upon approval of the State.

5. The Contractor will submit written reports which must be received by the Board no later than **November 1st** of each contract year.

CCNB Project Proposal FY 2023

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

Request for FY 2023 is year 3 of 3

Project leader and contact:

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Current and/or pending support for this project: Year 2 of the project has been funded by CCNB and is in progress. No current or other pending funding is available for year 3.

Executive Summary

Budbreak and growth in the greenhouse citrus nursery slows greatly during the winter months. Experimental evidence suggests that timed additions of light and heat can significantly improve budbreak and tree growth during the short-day conditions, but clear information is lacking about the optimum amount, wavelengths, and timing of the supplemental light. Initial investments and seasonal power usage for supplemental lighting and heat are large costs for the nursery, and better information is needed about what is the most effective and efficient combination of light and heat to secure good tree production during the winter months. Our project proposes to evaluate budbreak, shoot health, and shoot growth effects from **1) extended daylength or night interruption by supplemental lighting, 2) light and temperature preconditioning, and 3) variations in supplemental light spectral quality and intensity.** The work will be conducted under common greenhouse conditions, and results will be presented in a manner that can be readily adapted to commercial production. This project will systematically evaluate combinations of supplemental light and heat to provide clear usable

information for the citrus nursery about how to achieve budbreak and growth during November, December, and January, that is equivalent to nursery success in April.

Benefit to Citrus Nursery Industry

The combination of reduced budbreak and reduced tree growth during winter in the citrus nursery interrupts the production cycle and reduces profitability. Most nurseries stop or dramatically reduce budding of new trees during November-January, and without supplemental lighting and heating the growth of liners and budded trees is also greatly reduced during that same time. Early work in citrus nursery lighting demonstrated erratic growth benefits, depending on rootstock and other factors, during the winter months using supplemental incandescent and fluorescent lights (Nauer et al., 1979; Piringer et al., 1961; Warner et al., 1979; Young, 1961). A subsequent study indicated good growth improvements by night-interruption treatments during short days under growth chamber conditions (Brar and Spann, 2014). Our recent studies with modern high-pressure sodium (HPS) and light-emitting diode (LED) lighting have defined more clearly the actual growth benefit to a range of different rootstocks from extended daylength during the winter months in the greenhouse nursery (Bowman and Albrecht, 2021). But additional information is needed to guide choices by modern nurseries as to the most effective and economic combinations of light intensity, light spectrum, light timing, and heat to achieve good budbreak, plant growth, and tree health during winter months. This proposal specifically addresses CCNB Research Priority 1: "**Growing Citrus in screenhouses/greenhouses in containers; growing requirements including light, soil mixes, and nutrition**". The studies conducted under the project will use modern LED lighting to systematically evaluate a series of light and temperature treatments under winter greenhouse conditions. We will determine the effects of each treatment, and which are the most useful for commercial success. The first season of experiments (conducted October 2021 to March 2022), focused on the effects of daylength extension versus night interruption, the benefits from light and temperature preconditioning, and the relative influence of supplemental heat on these effects. During the first year of the experiment, percentage of budbreak and bud growth were measured under different temperature environments (79-90°F, 70-81°F and ≤ 72°F) and duration of plant exposure to the supplemental LED light at full intensity and full spectrum (no supplemental light, night interruption, and daylength extension to 16 hours). The first-year evaluation showed bud growth improvement on the plants under daylength extension to 16 hours combined with heat treatments. No growth improvement was observed with night interruption. However, plants respond to two aspects of light, namely quantity and quality. The light quantity is the intensity and duration of light exposure, and light quality is the spectra of light to which the plant is exposed. In the first year we tested the duration of light exposure and in the second year we are using a statistical model to test the combined effect of different intensities and spectral composition of light on budbreak and bud growth. The third-year project will be designed based on the results from the second year. We will replicate the best treatments from the second-year statistical model, and test different doses of 6-benzyladenine (BA) combined with supplemental lighting treatments to improve budbreak and plant growth. The results from the second and third year of the project will provide additional critical information that can be directly applied by citrus nurseries in the short-term, to use supplemental lighting in the most effective way. The studies proposed are being conducted

under standard nursery conditions and in a systematic and analytical manner, using good experimental design, and are expected to be suitable for refereed publication. The results of this work will increase scientific knowledge about light and heat effects on citrus and will serve as a springboard for future work relating to citrus nursery production, as well as more general citrus horticulture, physiology, and pathology.

Objectives

- *Objective 1.* Evaluate budbreak and growth effects from extended daylength and night interruption by supplemental lighting in the winter citrus nursery *(Completed, Year 1)*
- *Objective 2*. Evaluate budbreak and growth effects from light and temperature preconditioning in the winter citrus nursery *(Completed, Year 1)*
- *Objective 3*. Evaluate budbreak and growth effects from light spectral quality and intensity in the winter citrus nursery *(In progress, Year 2)*
- *Objective 4*. Confirm budbreak and growth effects from light spectral quality and intensity, and interaction when combined with BA in the winter citrus nursery *(Year 3)*

Workplan and Methods

Studies will be carried out by the post doc, Dr. Rayane Bisi, at 1.0 FTE in the USDA/USHRL greenhouses at Ft. Pierce, Florida, under the direction of Dr. Bowman and Dr. Albrecht. The scion used in the study will be Washington Navel orange (*Citrus sinensis*). The rootstocks used in the study will be Carrizo (*C. sinensis* × *Poncirus trifoliata*) and Rich 16-6 (*P. trifoliata*).

Citrus liners will be produced by seed in the USHRL greenhouses and grown in 2.5-liter pots using soilless potting mix and standard greenhouse nursery practices (Bowman and Albrecht, 2021). Artificial light treatments will be supplied by Heliospectra (Chicago, USA) Elixia LED fixtures, with variable spectra and intensity.

Year 3

Studies in year 3 will be based on results from year 1 and year 2 and focus on refinement of light intensity, spectral composition, and BA/no BA for optimal budbreak, plant growth, and health. The first-year study indicated that supplemental light extension to 16 hours combined with heating improve bud growth, but night interruption does not. In year 2 we are testing the effect of different light spectra and intensities on budbreak, bud growth and plant health. A statistical model is being used in year 2 to test a broad range of spectra and intensity combinations. While the second-year results are expected to provide a predicted optimum spectra and intensity, a third-year experiment is needed to replicate the optimum combination predicted from the second-year study. During the third year, supplemental lighting will include different spectra and intensities from the Elixia LED lighting combined with or without BA. The light spectrum and intensity treatments from year 3 will be based on the results from the second-year model. Budding will begin in the third week of November 2023.

Plant material. Each treatment will consist of 4 replications of 24 plants of Carrizo and 24 plants of Rich 16-6. As there will be 15 treatments, 1440 plants each of Carrizo and Rich 16-6 (15 treatments x 24 plants x 4 reps) will be needed for budding.

Planting of seeds. Seeds will be planted in May 2023. The number of seeds to allow for selecting uniform plants at transplant will be 2450 each of Carrizo and Rich 16-6 (25 racks of 98 cone-tainers each).

Transplanting of seedlings. Seedlings will be transplanted into 0.7-gal tree pots containing soilless potting medium in August-September. Of each Carrizo and Rich 16-6, 1500 seedlings will be transplanted.

Pre-treatment assessment of plants. Plant calipers will be measured, and plant health scored on the 3000 liners in October 2023. From those, 2880 liners (1440 each of Carrizo and Rich 16-6) will be selected and sorted so that each of the 15 treatments will contain healthy liners of the same average stem caliper (within rootstock).

Treatments. Different combinations of light spectra and intensities and BA, or no BA, will be evaluated. Two greenhouses will be used; both are located at the USDA-ARS Horticultural Laboratory in Fort Pierce, FL. Lighting will be studied at daylength extension to 16 hours and heating will be set at >70°F, <80°F.

Measurements

Air temperature, Air temperature will be monitored by Hobo dataloggers with one sample point per greenhouse measured hourly.

Leaf temperature. Leaf temperature will be measured on a subset of plants in each treatment using an infrared radiometer (MI-210, Apogee).

Light intensity and spectra. Light intensity and spectra for each treatment will be measured with a PG100N spectrometer (UPRtek).

Daily Light Integral (DLI). DLI values for each treatment will be determined using full spectrum quantum sensors (e.g., Apogee SQ-500-SS) and micro cache Bluetooth datalogger.

Slipping of buds. All liners will be budded in late November of 2023, using T-budding when slipping. Bark slipping of rootstock (or not) will be recorded. Budding will be spread over two days, so budding of all plants in replication 1 and 2 in all treatments will be done first, followed by rep 3 and 4.

Bud push and growth. Buds will be wrapped using standard budding tape. Budded liners will be unwrapped at 14-18 days after budding, and unwrapped liners will be looped to stimulate growth. Plants will be scored for bud survival, budbreak (>2mm), and scion shoot length (when

greater than 2 mm) at 2, 4, 6, 8, 10, and 12 weeks after budding (wab). At 12 wab, plants will be harvested, and the following will be measured:

- Scion shoot length
- Scion shoot diameter
- Rootstock diameter
- Number of fully expanded leaves
- Leaf area
- Scion dry weight

Physiological measurements: Up to four plants per treatment replication will be harvested for physiological measurements during the experiments; at least 20 plants per treatment replication will remain for the full duration of the bud push and growth study. Leaf chlorophyll levels will be determined using a SPAD 502 chlorophyll meter (Spectrum Technologies, Aurora, IL). Net CO_2 assimilation (A) and stomatal conductance to water vapour (g_{sw}) will be measured on the youngest fully expanded leaf using an infrared gas analyzer (Li-Cor 6800; Lincoln, NB, USA).

Project management and evaluation

Dr. Kim D. Bowman has 30 years of experience in citrus nursery and propagation studies, along with rootstock breeding and genetics. Dr. Bowman will serve as project director (PD), and the studies will be conducted in greenhouses under his management at the US Horticultural Research Laboratory in Ft. Pierce, Florida. Dr. Ute Albrecht is a plant physiologist at the University of Florida-SWFREC in Immokalee, Florida, has 15+ years of expertise working with citrus in greenhouse and nursery studies, and will be the co-PD under this project. Drs. Bowman and Albrecht have a long history of success working together on research studies and have co-authored 29 refereed publications together, including a study published last year on supplemental light use in the citrus nursery. We propose to provide the CCNB a written annual report in the summer to detail progress and findings of the preceding winter season of the funded project.

Literature Review

Supplemental light and heat are two components of the citrus nursery system that are important but have received little research attention in the modern era.

Day length effects on growth of young citrus trees were described (Piringer et al., 1961; Young, 1961), with pronounced differences between amounts of shoot growth in short day length and long day length. Growth of sweet orange on 'Troyer' rootstock trees was increased by extending day length 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 interpreted as indicating some rootstocks exhibited a strong positive growth response to long-day treatments, while other rootstocks did not (Warner et al., 1979). For 'Satsuma' mandarin on trifoliate orange rootstock, both shoot length and shoot fresh weight were significantly larger when plants were grown under 16-hour day length than when plants were grown under 8-hour day length (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 day length or the use of light to interrupt the dark period during short day periods, suggesting a phytochrome-mediated response (Brar and Spann, 2014). A recent study (Bowman and Albrecht, 2021) provided clear evidence that extending daylength with HPS or LED lighting increases growth of liners and budded sweet orange nursery trees in the greenhouse during short days. The study demonstrated a similar effect on a wide range of different rootstocks and propagation types (nucellar seeds, stem cuttings, and tissue culture), and provided quantitative measures of growth increase from specific supplemental light duration, spectra, and intensities.

Supplemental light has been studied in many plant systems and typically, improved or changed plant growth. The type, spectra, intensity, and timing of supplemental lighting can each have a large influence on the effects of light on most plants (Choong et al., 2018; Craig and Runkle, 2016; Demotes-Mainard et al., 2016; Gomez and Mitchell, 2015; Huché-Thélier et al., 2016; Islam et al., 2012). Up until now, citrus has received little research attention to evaluate influences of type, spectra, intensity, and timing of supplemental lighting.

Literature Cited

Bowman, K.D. and U. Albrecht. 2021. Improving winter growth in the citrus nursery with LED and HPS supplemental lighting. HortScience 56:21-27.

Brar, G.R.P.S. and T.M. Spann. 2014. Photoperiodic phytochrome-mediated vegetative growth responses of container-grown citrus nursery trees. Sci. Hortic. 176:112-119.

Campbell, J.A., R.H. Hansen, and J.R. Wilson. 1999. Cost-effective colorimetric microtitre plate enzymatic assays for sucrose, glucose, and fructose in sugarcane tissue extracts. J. Sci. Food Agric. 79:232-236.

Choong, T.W., J. He, L. Qin, and S.K. Lee. 2018. Quality of supplementary LED lighting effects on growth and photosynthesis of two different *Lactuca* recombinant inbred lines (RILs) grown in a tropical greenhouse. Photosynthetica 56:1278-1286.

Craig, D.S. and E.S. Runkle. 2016. An intermediate phytochrome photoequilibria from night-interruption lighting optimally promotes flowering of several long-day plants. Environmental and Experimental Botany 121:132-138.

Demotes-Mainard, S., T. Pérona, A. Corot, J. Bertheloot, J.L. Gourrierec, S. Pelleschi-Travier, L. Crespel, P. Morel, L. Huché-Thélier, R. Boumaza, A. Vian, V. Guérin, N. Leduc, and S. Sakr. 2016. Plant responses to red and far-red lights, applications in horticulture. Environmental and Experimental Botany 121:4-21.

Gomez, C. and C.A. Mitchell. 2015. Growth responses of tomato seedlings to different spectra of supplemental lighting. HortScience 50:112-118.

Huché-Thélier, L., L. Crespel, J.L. Gourrierec, P. Morel, S. Sakr, and N. Leduc. 2016. Light signaling and plant responses to blue and UV radiations - Perspectives for applications in horticulture. Environmental and Experimental Botany 121:22-38.

Inoue, H. 1989. Effects of day length and temperature on the vegetative growth and flower bud differentiation of satsuma mandarin. J. Jpn. Soc. Hort. Sci. 58:563-567.

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shorter poinsettias compared to high pressure sodium (HPS) lamps. Sci. Hortic. 147:136-143.
Nauer, E.M., S.B. Boswell, and R.C. Holmes. 1979. Chemical treatments, greenhouse temperature and supplemental day length affect forcing and growth of newly budded orange trees. HortScience 14:229-231.
Piringer, A.A., R.J. Downs, R.J., and H.A. Borthwick. 1961. Effects of photoperiod and kind of supplemental light on the growth of three species of citrus and *Poncirus trifoliata*. Proc. Am. Soc. Hort. Sci. 77:202-210.
Warner, R.M., Z. Worku, and J.A. Silva. 1979. Effect of photoperiod on growth responses of citrus rootstocks. J. Am. Soc. Hort. Sci. 104:232-235.
Young, R.H. 1961. Influence of day length, light intensity and temperature on growth, dormancy and cold hardiness of red-blush grapefruit trees. Proc. Am. Soc. Hort. Sci. 78:174-180.

Project Budget: Shown on the attached BUDGET PROPOSAL.

BUDGET PROPOSAL

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

Project Leader: Kim D. Bowman (USDA), Ute Albrecht (UF)

Project Start date: 1 May 2021

Proposed Total Budget (3 years) $ 293,643

The actual funded budgets for years 1-2, and the proposed budget for year 3, are shown below. The itemized proposed budget for year 3 is show on the attached BUDGET PROPOSAL.

Fiscal year 2021 Total Budget $ 108,277

Fiscal year 2022 Total Budget $ 91,594

Fiscal year 2023 Total Budget $ 93,772

Proposed Fiscal Year: 2023

Albrecht - University of Florida Budget

PERSONNEL SERVICES:

Post Doc, 12 months	$ 60,471	
Staff Benefits @ 10.2%	$ 6,349	
TOTAL UF PERSONNEL SERVICES:		$ 66,820

OPERATING EXPENSES:

SUPPLIES: ELISA kits, chemicals and reagents for carbohydrate analysis, pipette tips, reaction plates, gloves, and other supplies associated with laboratory procedures	$ 3,000	
TRAVEL:	$ 2,000	
TOTAL UF OPERATING EXPENSES:		$ 5,000
TOTAL UF Costs		$ 71,820
TDC @ 12%		$ 8,618
TOTAL University of Florida BUDGET REQUESTED:		$ 80,438

Bowman - USDA Budget

PERSONNEL SERVICES: None

OPERATING EXPENSES:

Laboratory/Greenhouse Supplies: $ 12,000		
Travel: None		
TOTAL USDA OPERATING EXPENSES:		$ 12,000
EQUIPMENT: None		
TOTAL USDA Costs		$ 12,000
IDC (10%) @ 11.111%		$ 1,334
TOTAL USDA BUDGET REQUESTED:		$ 13,334

TOTAL GRANT BUDGET FY 2023 (YEAR 3) $ 93,772

Signature of Requestor: Kim D. Bowman

Don Dillon

Don Dillon (Jan 18, 2023 15:07 PST)

PROGRESS REPORT

First year

In the first year of the project we evaluated budbreak, and shoot growth effects from lighting at three levels, 1) no supplemental light, 2) daylength extension to 16 hours (at full spectrum and full intensity), and 3) night interruption (1 hr at full spectrum and full intensity), combined with heating at three levels, 1) heating set at >79°F, <90°F, 2) heating set at >70°F, <81°F, and 3) no supplemental heating. Plant preconditioning was studied at the respective treatment light conditions (no preconditioning, daylength extension, and night interruption). Plants were scored periodically for bud survival, budbreak of buds grafted on the rootstock liners, and scion shoot length. The combination of light treatment and level of heating significantly affected the scion shoot growth (Fig. 1). Daylength extension to 16 hours and temperature combined increased scion bud growth.

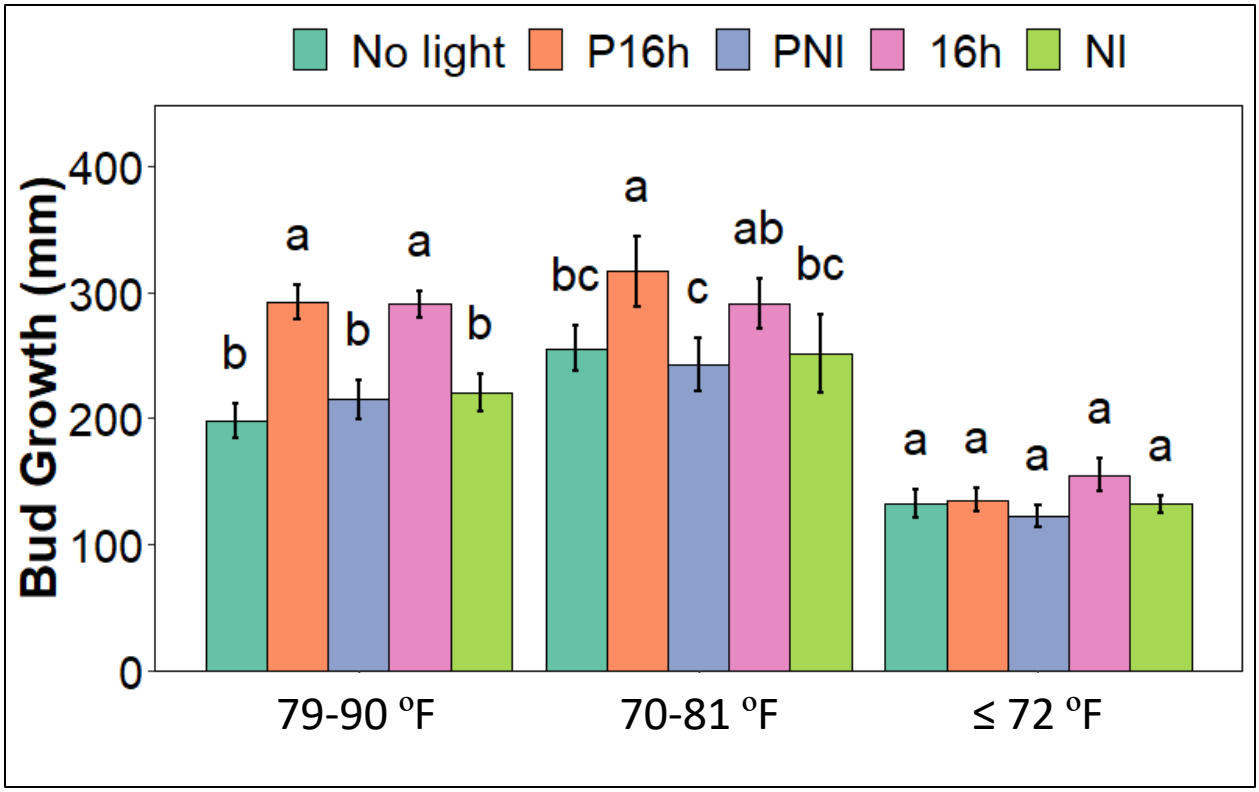

Fig 1. Bud growth of W. Navel on Rubidoux and Carrizo rootstocks at 12 weeks after budding, combining different light treatments and temperature environments. Means followed by different letters in each temperature treatment are significantly different at $P < 0.01$ (Tukey HSD test).

Second year

The second-year experiment was planned based on the results from the first year. During the second year, we are testing the effect of variations in supplemental light spectrum and intensity on the budbreak, bud growth, and plant health using a statistical model.

Plant material. Each treatment has 48 plants of Carrizo plus 48 plants of Rich 16-6. In May and June 2022, 2450 seeds from Carrizo and 2450 from Rich 16-6 were planted.

Transplanting of seedlings. In September, 1500 seedlings from each rootstock were selected for uniformity of plant size and transplanted into 0.7-gal tree pots containing soilless potting mix.

Budding. Carrizo and Rich 16-6 rootstocks were budded in November 21st with W. Navel scion, using the inverted-T method. Lights treatments started on the next day.

Treatments. Different combinations of spectrums and intensities are being evaluated. Two greenhouses are being used and are located at the USDA-ARS Horticultural Laboratory in Fort Pierce, FL. Lighting effects are being studied using daylength extension to 16 hours at different intensities and combinations of four spectra, 1) 450 nm, blue visible spectrum, 2) 660 nm, red visible spectrum, 3) 735 nm, far red spectrum, 4) 5700K, white visible light with peaks at 446nm, 534nm and 625 nm. Heating is set at >70°F, <81°F.

Plants will be scored for bud survival, budbreak (>2mm), and scion shoot length (when greater than 2 mm) at 2, 4, 6, 8, 10, and 12 weeks after budding (wab). In February 13rd 2023, at 12 wab, plants will be harvested and measured.

Fig 2. One of the two greenhouses in the Second Year experiment, showing plants two days after budding and with light spectra treatments.

BOW-23

Final Audit Report 2023-01-19

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Signer jan.moreno@usda.gov entered name at signing as Janet S Moreno
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Document e-signed by Janet S Moreno (jan.moreno@usda.gov)
Signature Date: 2023-01-19 - 2:25:02 PM GMT - Time Source: server- IP address: 147.49.240.160

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