PIP CAP
Precise Indoor Propagation

1st Annual PIP-CAP Meeting

Agenda:

1. Introduction Project and Slack groups (Mark)
2. Program Coordinator and budget overview (Lizeth)
2: Groups (Group Leaders)
3. CA Trip Summary (Mark and Ricardo)
4. Student and Postdoc Presentations
    - Sam Humphrey: Rooting plug plants from tips of different sizes
    - Pooja Tripathy: Effect of artificial chilling treatment on vegetative growth and runnering of 'Albion' and 'Fronteras' strawberry propagation transplants
    - Xi Luo: Progress in identifying DNA variants associated with runnering and flowering traits in strawberries
5. Adjourn and invite people to stay for the virtual meet and greet for students
6. Meet & Greet for Students, staff, post-docs and PIs (not mandatory)

Development and Integration of Next Generation Propagation Strategies to Increase the Resilience of The US Strawberry Supply Chain

USDA-NIFA Award: 2021-51181-35857
Budget: $5,294,195

PIP CAP

Precise Indoor Propagation

Mission:

Provide the industry with controlled environment protocols to propagate strawberries

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- Plant Physiology
- Plant Genetics
- Industry Economics
- Plant Performance
- Technology Transfer

Outcomes:

- Technology transfer: CE protocols to propagate strawberries.
- Fundamental knowledge on physiology, genetics, economics and supply chain.
- Building networks

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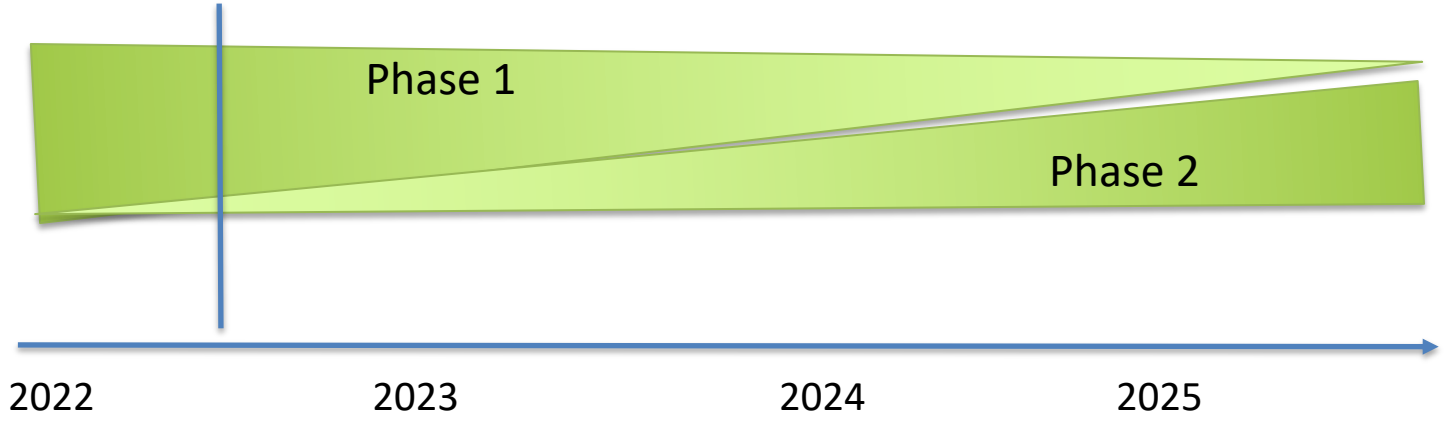
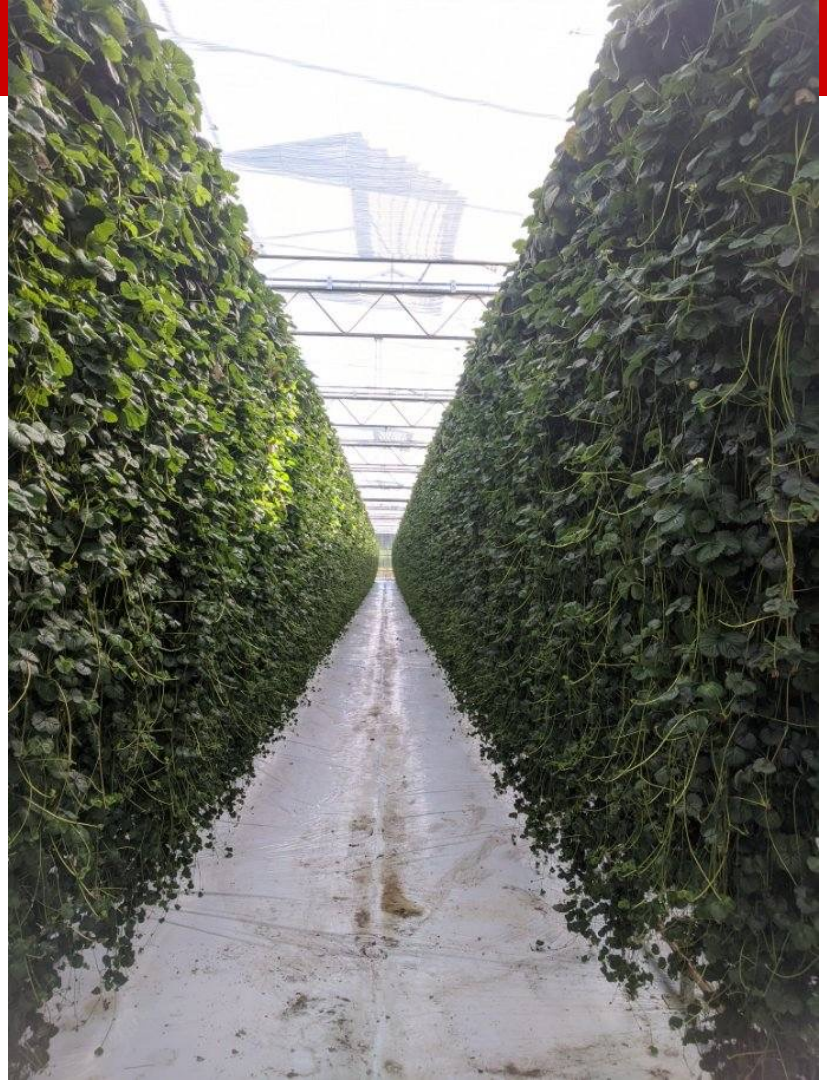
Phase 1: Acquiring fundamental knowledge

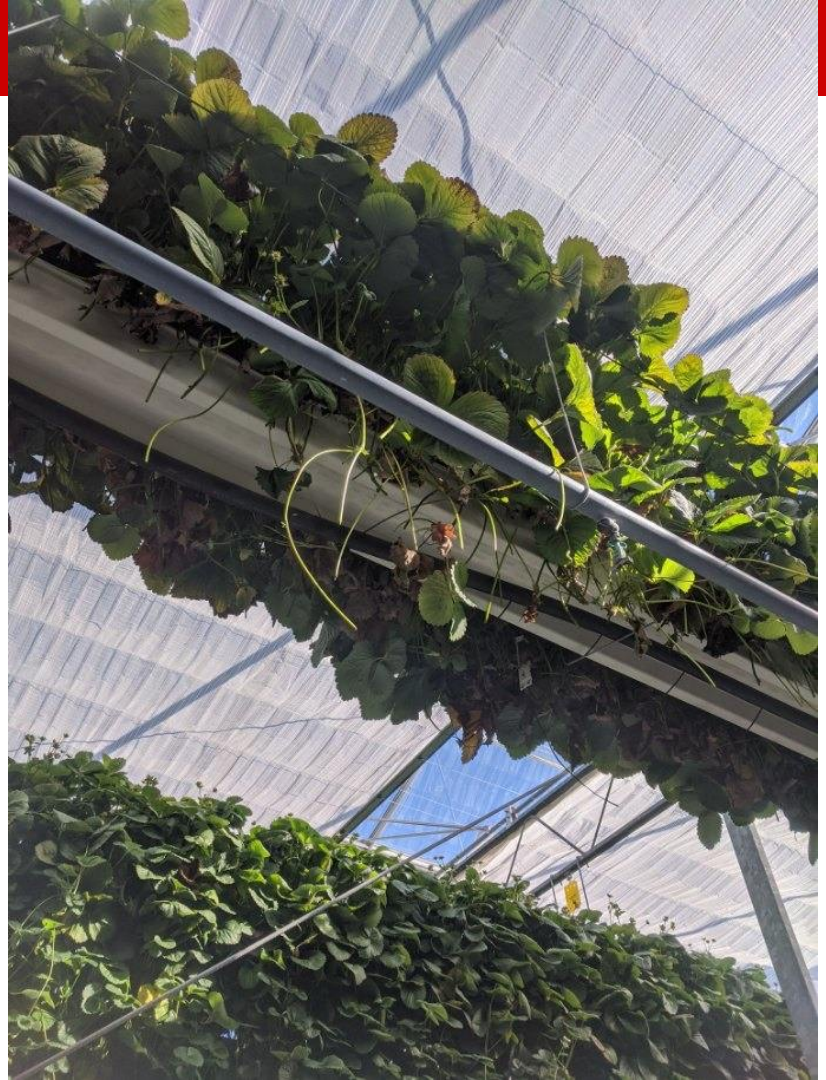
Phase 2: Performance and technology transfer

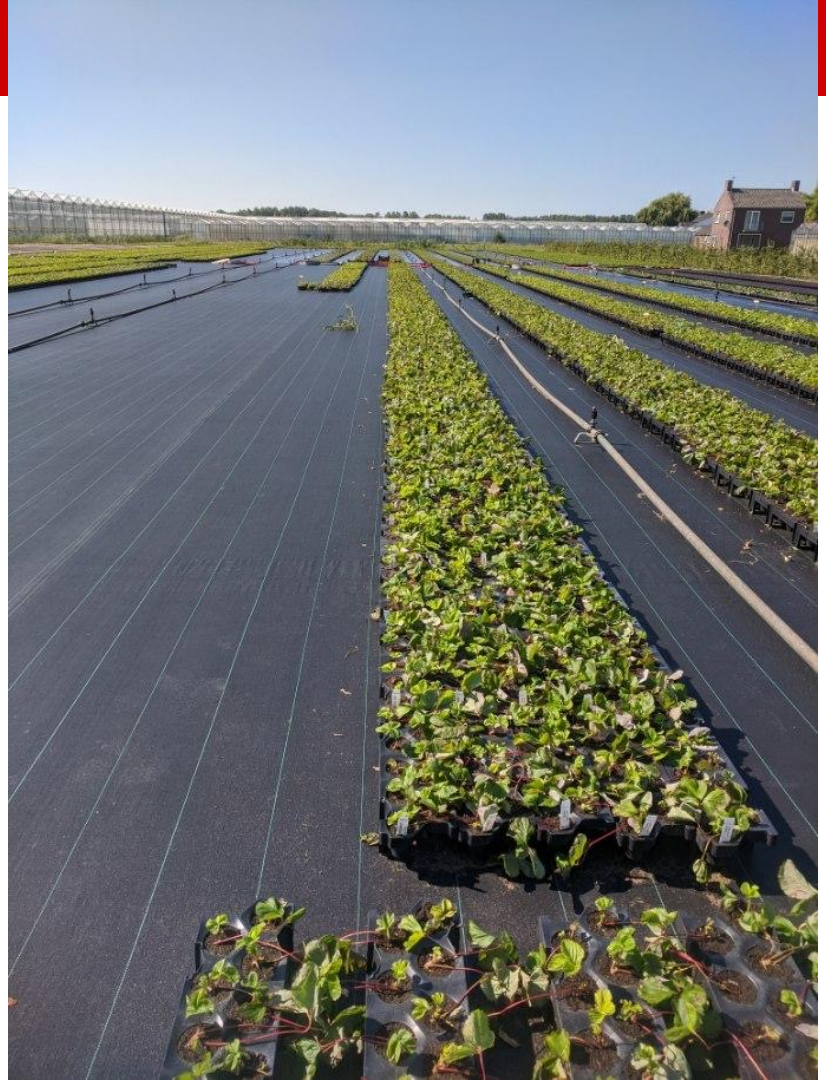


Today:

- Introduction of groups
- A short summary of our stakeholder visit in June 2022
- Brief research updates
- Student/Post-Doc meet and greet







Questions?

- Can we adopt similar practices for the US?
- Can we move things into Completely enclosed environments?
- Chilling/Storing/Conditioning?

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- Plant Physiology
- Plant Genetics
- Industry Economics
- Plant Performance
- Technology Transfer

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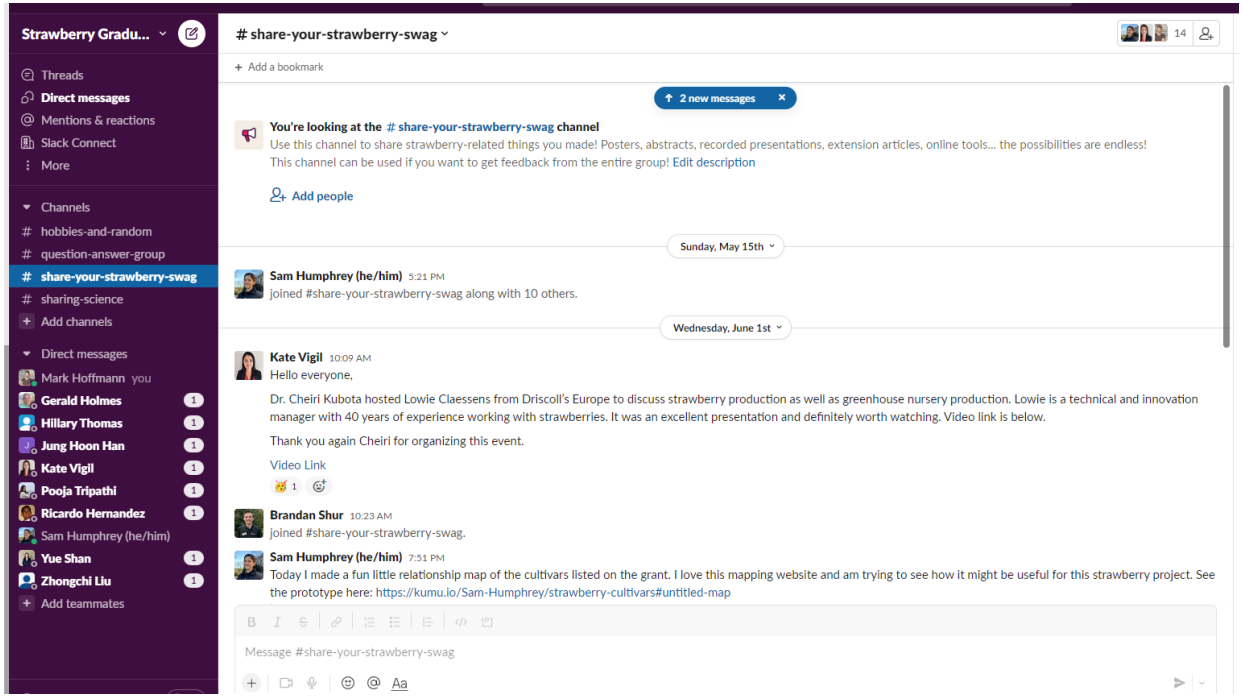

SLACK:

- Q&A Group
- Sharing science (interesting pubs/talks/videos)
- Share your strawberry swag (you want others to see/talk about your research?)
- Hobbies & Random

https://strawberries-pip.cals.ncsu.edu/

Thank You

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Program Coordinator for PIP-CAP

K. Lizeth Vigil
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575-993-8212

Education History

BS in Education from New Mexico State
MS in Administration from Concordia University-Portland

Work History

Public Education for 14 Years

- High school teacher
- IEP Coordinator

NC State University with Dr. Mark Hoffmann

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Budget Overview

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Account	Name	Total Sub. Amount	1st Distribution Amount	PTD Avtivity	Balance Available
500023	US Davis	$210,000	$125,253	$0.00	$125,253
500024	Univ. of Florida	$377,839	$234,389	$736.16	$233,653
500034	Ohio	$447,504	$252,660	$34,893.75	$217,766
562798	Virginia	$79,237	$30,561	$2,099.32	$28,462
568230	Univ. of California	$138,921	$80,570	$0.00	$80,570
569154	Univ. of Maryland	$500,000.00	$306,122.00	$36,186.97	$269,935.03
569164	Cal Poly	$217,517	$153,660	$0.00	$153,660
569176	Cornell	$179,990	$105,123	$6,611.58	$98,511
569201	Rutgers	$335,000.00	$207,859.00	$12,452.61	$195,406.39
569206	USDA	$304,050	$241,368	$0.00	$241,368
573704	Hoffmann		468,241.00	$86,036.53	382,204.47
569148	Tregeagle		$156,291	$13,696.81	$142,594
569149	Schweizer		169,063.00	$15,029.07	154,033.93
569150	Hernandez		342,431.00	34,033.83	308,397.17
569151	Fernandez		138,986.00	$4,170.77	134,815.23
569152	Devel-Jackson		139,901.00	$2,164.44	137,736.56
	Total			$248,111.84	$2,904,366

Team Leads Presentations

Objective 1.

Characterization of mother plant physiological responses to the environment.

Characterization of mother plant physiological responses to the environment –shoot

Sam Humphrey

Ricardo Hernandez

- Current Activities: CO_2 and Light intensity chamber set up (Sam), Transplant rooting capacity experiment completion (Sam). Arrival of new PhD student (Moein).

- Upcoming research activities: Execution of CO_2 and Light experiment, set up and experiment for light distribution, light quality, and photoperiod.

Moein Moosavi-Nezhd

Characterization of mother plant physiological responses to the environment – root zone

- Current Activities: Completed initial substrate formulations and first round of characterization. Container modeling (substrate physical properties) is ongoing.
- Next Immediate Steps: Coordinating with Hernandez, Kubota, and Boldt on selecting a "common" substrate for all lab groups to use in testing and trials. Mixing/preparing that product and distribution to lab groups.
- Next Fiscal Year: Complete substrate characterization and container modeling. Conduct and complete strawberry plant growth trials in experimental mixes, beyond the one used for/across all groups.

Brian Jackson

Brandan Shur

Logan Hooks

1.2a Nutrient optimization of mother plants (USDA-ARS)

USDA Agricultural Research Service

Current activities:

1. Evaluate NO_3^-:NH_4^+ on runner production and daughte r plant quantity and quality (July – Nov 2022)
2. Test viability of multiple hydroponics setups for future nutrient studies (Aug – Oct 2022)

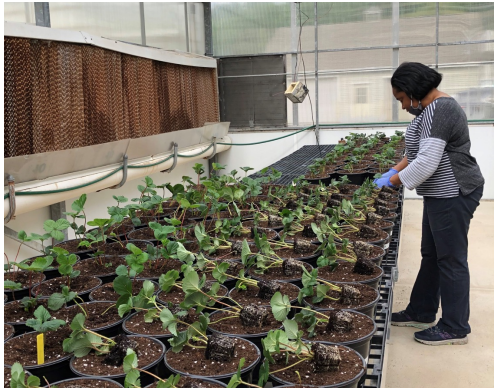
Upcoming research activities:

1. Repeat NO_3^-:NH_4^+ study in new indoor space (fall/winter 2022-2023)
2. Impact of EC on mother plant and runner production (greenhouse; winter/spring 2023)

Current personnel:

Jennifer Boldt, PI

Erin Yafuso, Post-doc



Transplant day! (Mona-Lisa Banks, technician)

Objective 2.

Development of environmental protocols for transplant establishment, conditioning and long-term storage.

Objective 2

Environmental protocols for transplant establishment, conditioning (runnering/flowering), and long-term storage

UPDATE

Chieri Kubota (Ohio State Univ.)

Edward Durner (Rutgers Univ.)

Celina Gomez (Purdue Univ.)

Mark Hoffman (NC State Univ.)

Obj. 2 **Environmental protocols for transplant establishment, conditioning (runnering/flowering), and long-term storage**

Team members:

Chieri Kubota
The Ohio State University

Edward Durner
Rutgers University

Celina Gomez
Purdue University

Mark Hoffmann
NC State University

Stage	Objective	Research	Outcome
OBJ. 2 Environmental protocols for transplant establishment, conditioning (runnering/flowering), and long-term storage.			
Propagation Transplants 	**OBJ. 2.1** Environ. strategies to condition Propagation transplants for optim-ized propagation behavior.	**Conditioning Treatments** Chilling; Nitrogen Rates	 **Outcome:** Plant material with multiple microscopic crowns with high runnering capacity
Plug Plants 	**OBJ. 2.2** Environ. strategies to condition plug plants for a predetermined flowering behavior.	**Conditioning Treatments** Far-red light for short day cultivars, Night interruption red light for long day cultivars, Nitrogen Pulses	 Conditioned transplants to have early and higher fruit production yield
Unrooted and rooted daughter plants 	**OBJ. 2.3** Environ. recipes to maintain unrooted + rooted daughter plant in storage with minimum impact on plant quality	Low temp. and storage days, Low temp. + light combin-ations to reach photo-synthesis = respiration compensation point and long storage time	 High quality plant material (plug plant) coming from storage for either fruit or daughter plant production

Obj. 2.1 – Conditioning plants for propagation, update

Chieri Kubota
The Ohio State University

- Bare root plants were received for three cultivars “Albion, Monterey and Fronteras” in November 2021
- Greenhouse was set up for runnering
- A grad student (Pooja Tripathi) joined in January 2022
- The first experiment began in April 2022 using two cultivars (Albion and Fronteras) to test artificial chilling to improve the vigor of propagation transplants.

Obj. 2.2 – Conditioning plants for fruit production, update

Edward Durner
Rutgers University

- Bare root plants were received for three cultivars “Albion, Chandler and Fronteras” in November 2021.
  - Fronteras did not establish well in the greenhouse
  - ‘Ruby June’ was added as alternative material
- Started working towards “protocols development” to develop high quality plug/tray plants and their flower mapping data
  - Photoperiodic lighting quality (red, far-red, and blue light)
  - Nitrogen pulse treatment
  - Correlating flower mapping data with flower and fruit production in greenhouse, high tunnel, and open field

Obj. 2.3 – Low-temperature storage of unrooted or rooted runner tips, update

Celina Gómez
Purdue University

- Project site moved to Purdue University
  - Experimental design will be updated based on the facility availability at Purdue
- Project starting date will be January, 2023
- Graduate student joined the lab in August 2022
- Need to arrange plants (and select cultivars) this fall
- Seeking collaborations with commercial nurseries for getting their runner tips or plugs to use in storage experiments

Objective 3.

Development of a genetic matrix, based on phenotypic responses to environmental treatments.

Genetics Team

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USDA-SCRI Project:
Development and Integration of Next-Generation Propagation Strategies to Increase the Resilience of the US Strawberry Supply Chain

https://strawberries-pip.cals.ncsu.edu/

UNIVERSITY OF MARYLAND

Team Members

Dr. Zhongchi Liu
Professor

Dr. Xi Luo
Postdoc

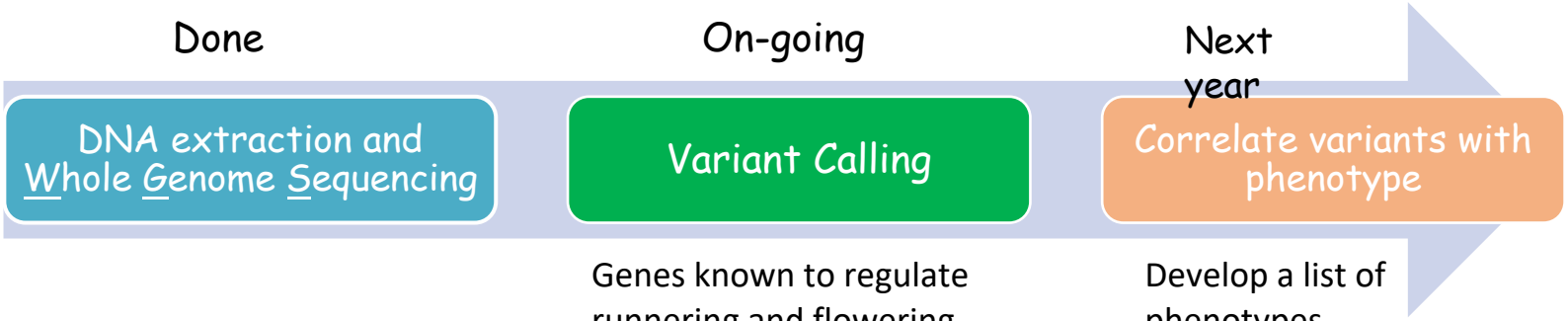
Ms. Christina Ippoliti
PhD student

Advisors to the team

Dr. Gina Fernandez
NCSU

Dr. Courtney Weber
Cornell

Project summary



Short-Day

- Brilliance
- Camarosa
- Chandler
- Fronteras
- Radiance
- Ruby June

Day neutral

- Albion
- Cabrillo
- Monterey
- Moxie
- Portola
- Finn

Genes known to regulate runnering and flowering In *Fragaria vesca*

- *CO*
- *FT (FT1, FT2, FT3)*
- *SOC1*
- *TFL1*
- *GA20ox4*
- *RGA1*
- *DAM*

Develop a list of phenotypes

- Runner proliferatively or not
- Flowering time
- Vigor (number of leaves?)
- Refined day length
- Chilling hour requirement?

Objective 4.

Determine expected economic costs/returns to industry of adopting developed techniques, and estimate the economic impact of adoption on the US strawberry supply chain.

Economics Team

Rachael Goodhue

Daniel Tregeagle

Completed and Ongoing

- Review literature on strawberry and specialty crop supply chains
- Description of current “conventional” supply chain
- Identify nursery business characteristics
- Develop framework for CA strawberry nursery production cost

Planned for 2022-23

- Design of summer 2023 interview / focus group discussion
- Seek and receive IRB approval
- Conduct interviews / focus groups to quantify supply chain and production costs

Economics is about understanding the aggregate outcomes of tradeoffs made by individuals

- More “vigorous” plants vs. higher production costs? [quality]
- Do invest in building tabletops now, later, or never? [time]
- Should we produce more fresh bare root or frigo plants? [form]

Quantifying the production costs and supply chain allows us to analyze these (and other) tradeoffs

Objective 5.

Translation and integration of new propagation systems with industry partners.

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Plant Performance

Objective 5: Translation and integration of new propagation systems with industry partners

5.1: Validation and scale-up of PIP and Greenhouse Protocols
5.2: Development and of field-based propagation protocols
5.3: Nationwide transplant evaluation

PIP-CAP: Objective 5

Gerald Holmes
Director,
California Strawberry Center

CAL POLY

Shinsuke Agehara
Assistant Professor, UF

UF UNIVERSITY of FLORIDA

Courtney Weber
Assoc. Professor
Cornell University

Cornell University

Oleg Daugovich
Field Advisor,
Ventura Co.

Giuliano Galdi
Field Advisor,
Siskiyou Co.

UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

Mark Hoffmann
Small Fruits Extension Specialist, NCSU

Gina Fernandez
Distinguished Professor
NCSU

NC STATE UNIVERSITY

Students and Staff

Emma Volk
Research Assistant
MS Student
Greenhouse Nursery Operations

NC STATE UNIVERSITY

Michael Palmer
PhD-Student
Transplant Evaluation and Optimization

NC STATE UNIVERSITY

Samantha Simard
MS-Student
Transplant Evaluation

CAL POLY

2022-2023: Trails

CAL POLY

Evaluate optimal planting date for rooted tips

NC STATE UNIVERSITY

Evaluate field performance of PIP rooted tips
Develop optimal chilling protocols for tray plant production (in collaboration with Kubota & Durner)

UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

Evaluate optimal row-cover use in field nurseries

Objective 6.

Development of extension and outreach services and products for industry and public stakeholders.

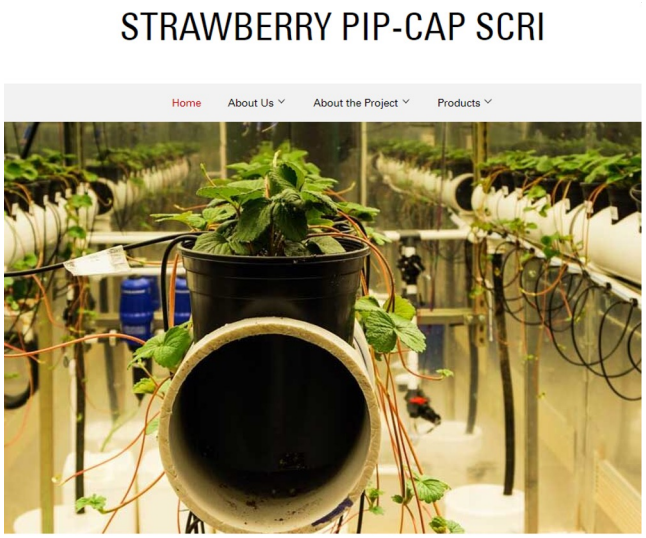
Extension & Outreach Team Members

- Peter Nitzsche
  - Agriculture & Natural Resources Agent, Rutgers NJAES Cooperative Extension of Morris County
- Mark Hoffmann
  - Small Fruits Extension Specialist, North Carolina State Extension, NCSU.
- Oleg Daugovich
  - Strawberry Vegetable Crop Advisor, Cooperative Extension Ventura County, UC ANR
- Shinsuke Agehara
  - Assistant Professor of Horticulture, Institute of Food & Agricultural Sciences, UF
- Jayesh Samtani
  - Small Fruit Extension Specialist, Virginia Agriculture Experiment Station, VT
- Giuliano Galdi
  - Agronomy and Crops Advisor, Cooperative Extension Siskiyou County, UC ANR

Current Activities

Year Plan

- Website Development (https://strawberries-pip.cals.ncsu.edu/)



Next Fiscal

- Blog / Newsletter Development
- Video on CA Strawberry Nursery Industry
- Work with other teams to document their research
- Student exchange

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Stakeholder Visits California Jun 26 – Jul 1, 2022

Who was travelling?

- Students & Staff

Emma Volk, Rocco Schiavone, Sam Humphrey, Yue Shan, Jung Hoon Han, Christina Ippoliti

- PIs

Mark Hoffmann, Ricardo Hernández, Peter Nitzsche, Zhongchi Liu, Heidi Schweizer

Planning/Management

Lizeth Vigil

Who did we visit?

Cal Poly

University of California Agriculture and Natural Resources

USDA Agricultural Research Service

Driscoll's Only the Finest Berries™

Lassen Canyon Nursery, Inc.

Plant Sciences Inc. PSI Advancing Agriculture through Science

naturipe since 1917 FARMED FRESH™

plenty

What did we learn?

- California nursery system
- California strawberry production system
- Issues and expectations

CA Nursery Systems: Summer before planting

CA Nursery Systems: June after planting

CA Nursery Systems: Spring-Summer after planting

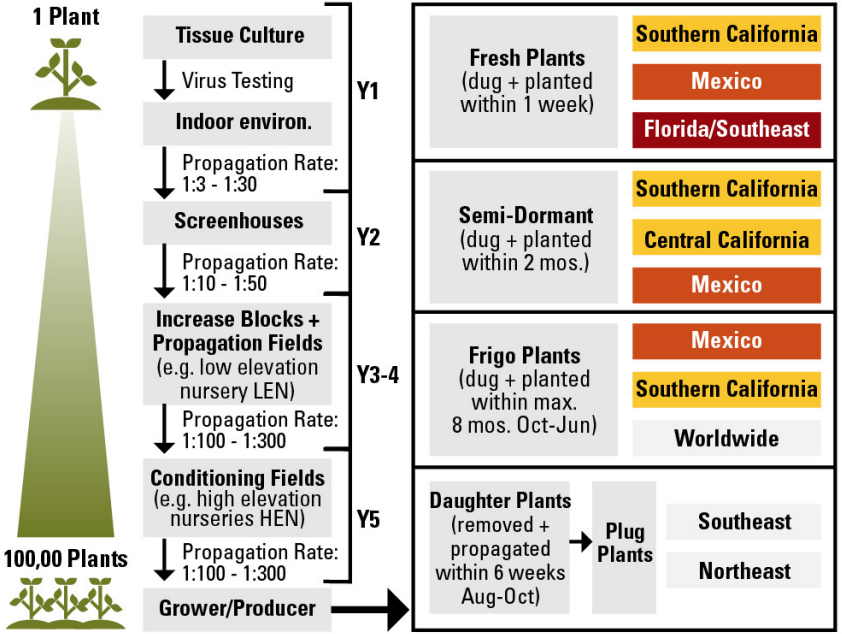
CA Nursery Systems: Spring-Summer after planting

CA Nursery Systems: Shortly before harvest

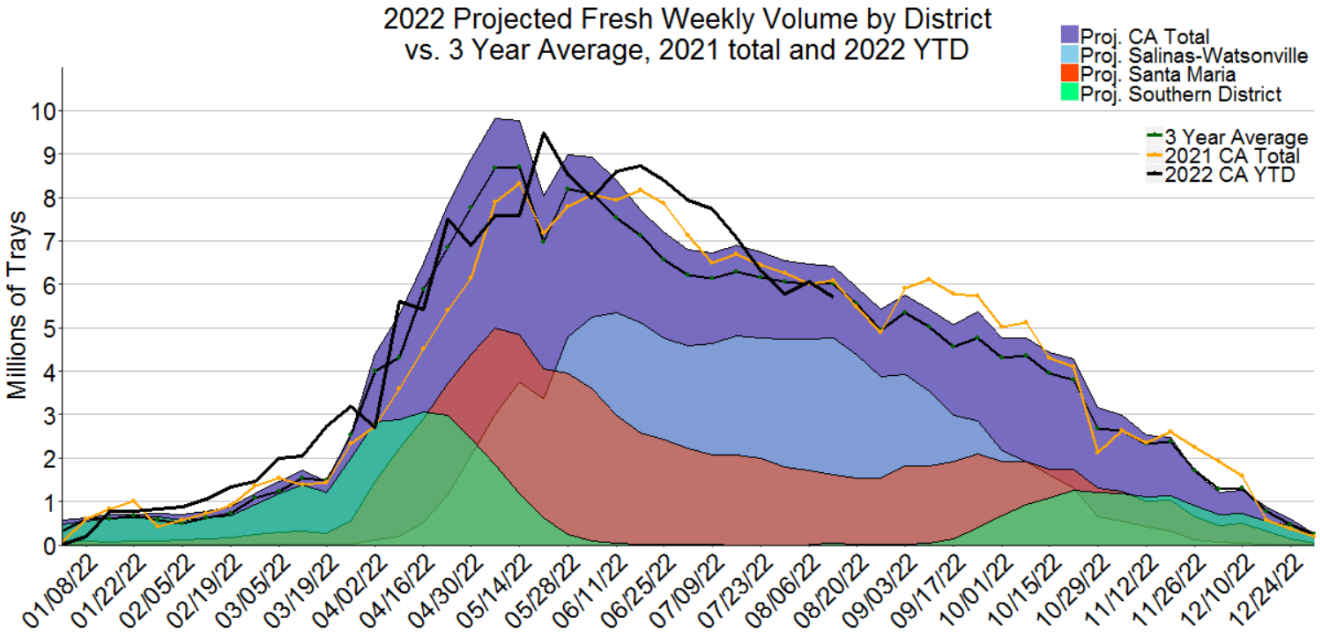
CA Nursery Systems: Harvest (Sep-Nov)

Video Clip

CA Nursery Systems: Shipping/Storing (Sep-May)



CA Production



2022 California fresh volume of 5,708,083 trays is below the projected total of 6,421,381 trays for this week.

2022 volume projections are calculated using this year's acreage estimates multiplied by the 4-year average yields per acre, per district.

CA Production

Crop	Area	2022 Acreage	% change to 2021
Fall Planting Winter, Spring, Summer Production	Oxnard/Santa Maria Watsonville/Salinas	30,383	+6.4%
Summer Planting Fall – Winter Production	Oxnard/Santa Maria Watsonville/Salinas	7,643	-15.1%
Mexico	Central Mexico Baja	40,900	+27%
Florida	Hillsborough Co.	12,169	+1.4%

Expectations and Issues

- Fundamental knowledge on plant physiology and technology transfer two key expectations
- CA industry tightly connected to Mexico industry
- Key definitions are lacking (e.g. high quality plant)

Thank You

mark.hoffmann@ncsu.edu
ricardo_hernandez@ncsu.edu

CFAES

Effect of artificial chilling treatment on vegetative growth and runnering of ‘Albion’ and ‘Fronteras’ strawberry propagation transplants

Pooja Tripathi
PhD student
Kubota Lab
Department of Horticulture and Crop Science

The Ohio State University
College of Food, Agricultural, and Environmental Sciences

Objective 2: Development of environmental protocols for transplant establishment, conditioning and long-term storage.

Specific objective 2.1: Environmental strategies to condition young plants for optimized propagation behavior.

Objective:

To examine the effects of various levels of artificial chilling treatments on vegetative growth and runnering capacity of two strawberry cultivars.

Hypothesis:

- Chilling treatment will promote vegetative growth, runnering and increase the number of daughter plants.
- Increase in chilling hours will make the plants more vegetative.

Chilling requirements of strawberry cultivars in conventional propagation.

- For Albion, 10-18 days of supplemental chilling is recommended, depending on how much in field chill the plants got. If the plants get 600 hours of in-field chill, 10 days of supplemental chilling is recommended before transplanting.

- Likewise, for Fronteras, a short-day cultivar, 4-7 days supplemental chill with at least 250 hours in-field chill is recommended prior to transplanting. (Source: I.A Rainwater, Strawberry Licensing Field Representative, UC Davis, personal communication)

Table 1: Calculation of chilling treatments

Cultivars	Low end of minimum	Low end of minimum + 50% increase
Albion	600+240 = 840 h	840+420 = 1260 h
Fronteras	250+96 = 346 h	346+173 = 519 h

Treatments

Table 2: Chilling treatments for Albion

Factors	Levels	Values
Chilling	3	0 h, 800 h, 1200 h

Table 3: Chilling treatments for Fronteras

Factors	Levels	Values
Chilling	3	0 h, 350 h, 500 h

CFAES

Methodolog

Harvestin g daughter plants

transplan t assessme nt

Note: Photosyn -hour photoperiod du





Date of transplant: 8/11/2022

Data collection

Weekly

- Number of runners
- Length of runners
- Number of daughter plants
- Number of flower trusses removed

Bi-Weekly

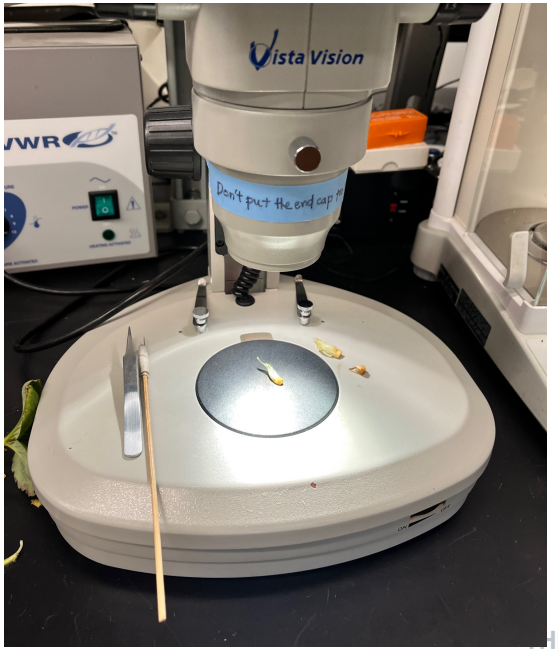
- Petiole length of mother plant
- Number of leaves of mother plant
- Number of crowns in mother plant

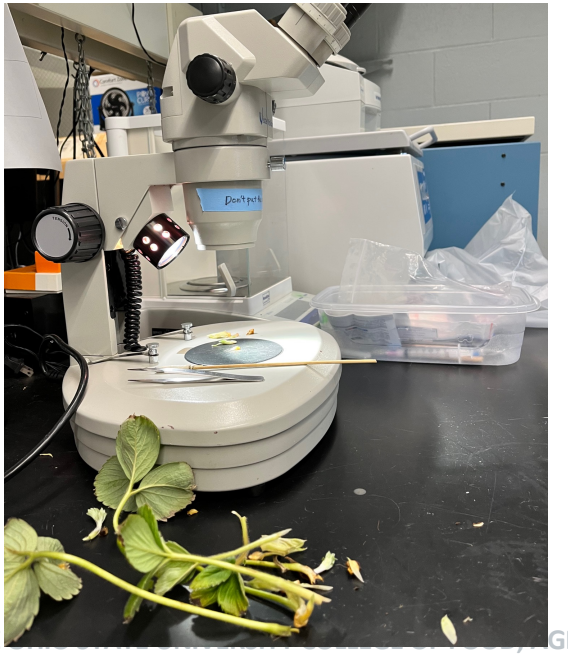
Two times measurement of leaf area index and photosynthesis of mother and daughter plants

End of the experiment:

- Crown diameter of daughter plants
- Weight and number of daughter plants (FW and DW) per mother plant
- Weight of the stolon and mother plant
- Rooting capacity of daughter plants

Before transplanting





Plant architectural analysis (microscopic flower and runner mapping) of mother plants

Thank you!

Acknowledgement

Advisor: Dr. Kubota

Kubota lab members

Mark Kroggel

Jason Hollick

John Ertle

Jeffrey Bates

USDA NIFA Specialty Crop Research Initiative (SCRI)

USDA National Institute of Food and Agriculture

U.S. DEPARTMENT OF AGRICULTURE

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