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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)

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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 <u>propagate strawberries</u>

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Precise Indoor Propagation

Plant Physiology

Plant Genetics

Industry Economics

Plant Performance

Technology Transfer

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Outcomes:

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

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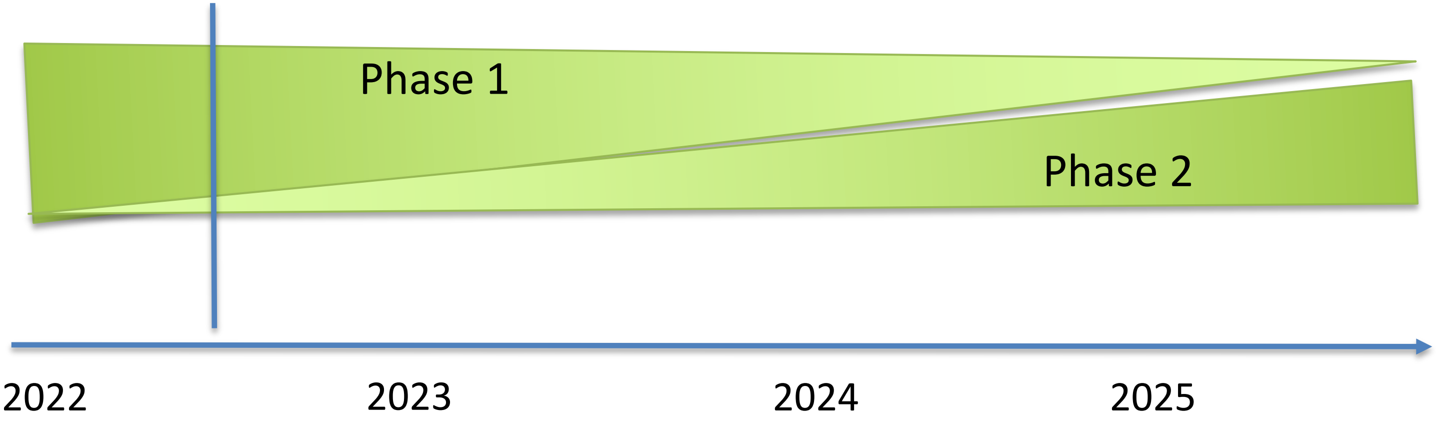
Phase 1: Acquiring fundamental knowledge

Phase 2: Performance and technology transfer



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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 develop 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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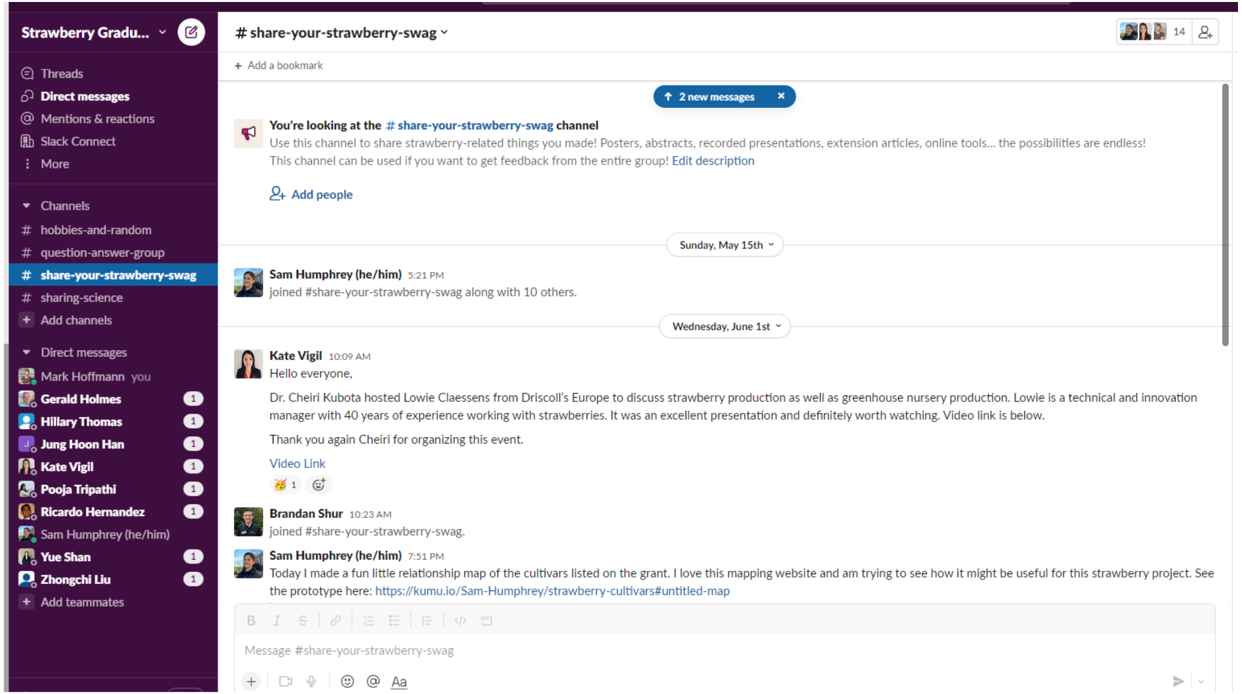

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SLACK:

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

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

Thank You

mark.hoffmann@ncsu.edu

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Program Coordinator for PIP-CAP

K. Lizeth Vigil
kvigil@ncsu.edu
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

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Team Leads Presentations

Plant Physiology

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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)

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Plant Physiology

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
- Mark Hoffmann and Michael Palmer (PhD Student) are joining this Objective: Impact of chilling on floral development and plant performance

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

Plant Genetics

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Objective 3.

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

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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

Done

On-going

Next year

DNA extraction and Whole Genome Sequencing

Variant Calling

Correlate variants with phenotype

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?

Industry Economics

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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

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Plant Performance

Objective 5.

Translation and integration of new propagation systems with industry partners.

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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

Shinsuke Agehara
Assistant Professor, UF

Courtney Weber
Assoc. Professor
Cornell University

LEARN BY DOING CAL POLY

UF UNIVERSITY of FLORIDA

Cornell University

Oleg Daugovich
Field Advisor,
Ventura Co.

Giuliano Galdi
Field Advisor,
Siskiyou Co.

Mark Hoffmann
Small Fruits Extension Specialist, NCSU

Gina Fernandez
Distinguished Professor
NCSU

UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

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

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CAL POLY

2022-2023: Trails

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Evaluate optimal planting date for rooted tips

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

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Evaluate optimal row-cover use in field nurseries

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Technology Transfer

Objective 6.

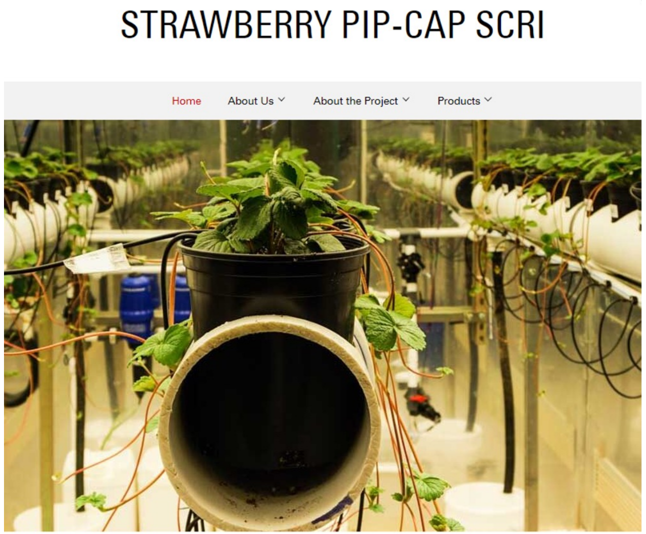
Development of extension and outreach services and products for industry and public stakeholders.

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

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



Next Fiscal Year Plan

- 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?

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USDA ARS Agricultural Research Service

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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

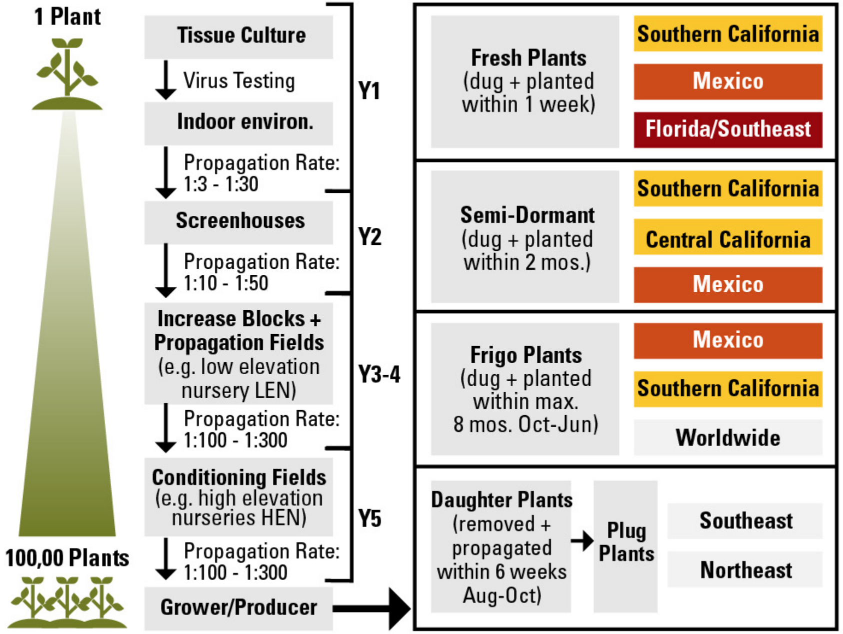
CA Nursery Systems: Spring-Summer after planting

CA Nursery Systems: Shortly before harvest

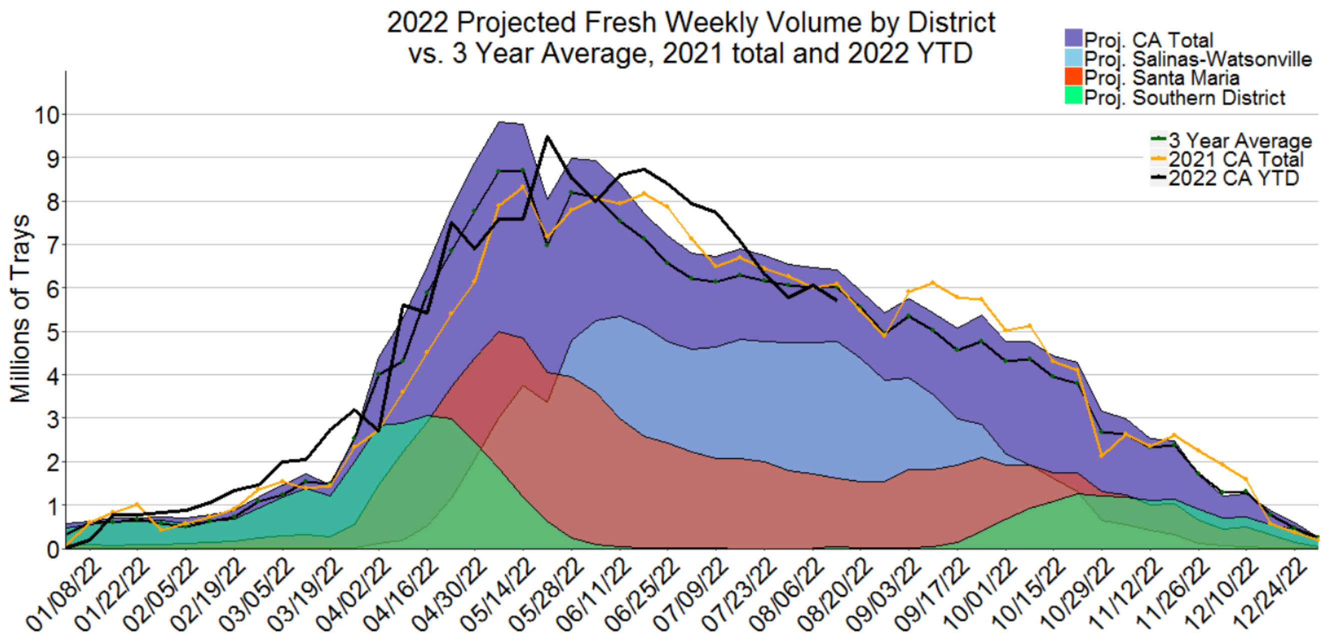
CA Nursery Systems: Harvest (Sep-Nov)

[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.

CFAES

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

Note: Photosyn -hour photoperiod du





Date of transplant: 8/11/2022

CFAES

Data collection

Weekly

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

Bi-Weekly

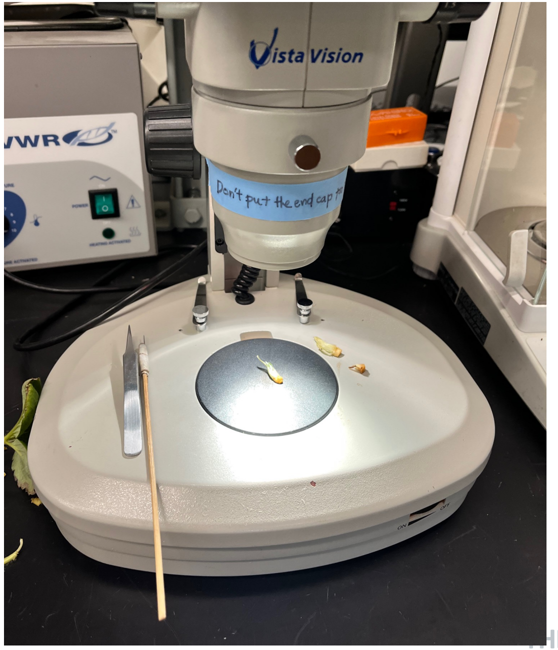
- Petiole length of mother plant
- Number of leaves of mother plant
- Number of crowns in mother plant

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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Rooting Efficacy of Different Size Strawberry (*Fragaria ananassa*) Tips in a Controlled Environment Propagation System

Samson Humphrey, Ricardo Hernández, & Mark Hoffmann
North Carolina State University
Department of Horticulture
SCRI PIP-CAP Annual Meeting, 2022

Introduction

Introduction

Three areas of optimization:

Introduction

Three areas of optimization:

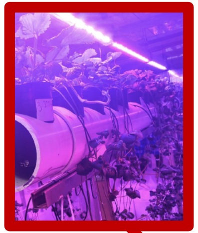
Mothers produce daughters
(Photo courtesy: Xiaonan Shi)

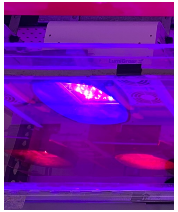
Introduction

Three areas of optimization:

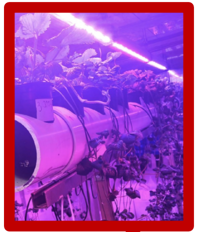
Mothers produce daughters
(Photo courtesy: Xiaonan Shi)

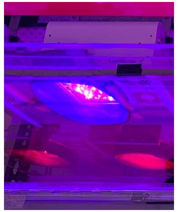
Daughters root and grow





Introduction

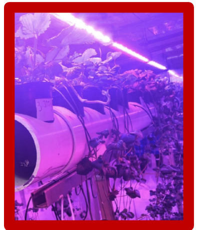


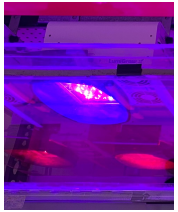


Introduction

Daughters from 1 stolon*

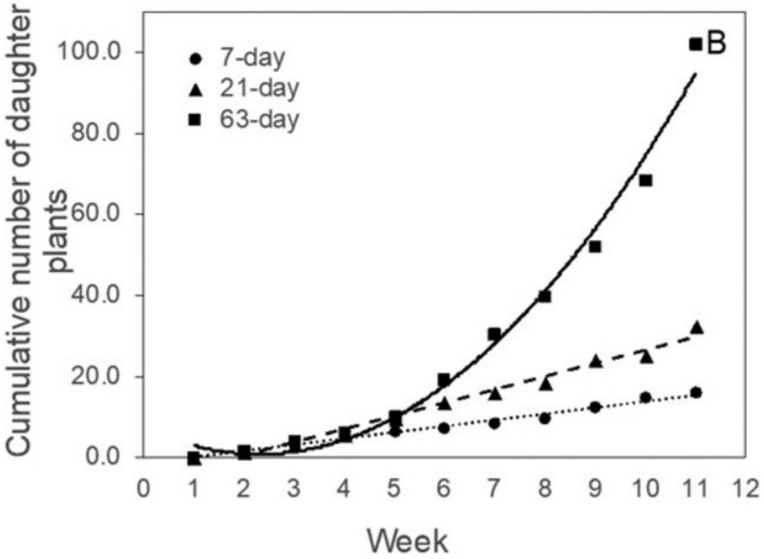
*Shi, et al. 2021: Timing of Stolon Removal Alters Daughter Plant Production and Quality in the Ever-bearing Strawberry 'Albion', HortScience
**Xu & Hernandez 2021: The Effect of Light Intensity on Vegetative Propagation Efficacy, Growth, and Morphology of "Albion" Strawberry Plants in a Precision Indoor Propagation System, MDPI Applied Sciences





Introduction

Daughters from 1 stolon*



*Shi, et al. 2021: Timing of Stolon Removal Alters Daughter Plant Production and Quality in the Ever-bearing Strawberry 'Albion', HortScience
**Xu & Hernandez 2021: The Effect of Light Intensity on Vegetative Propagation Efficacy, Growth, and Morphology of "Albion" Strawberry Plants in a Precision Indoor Propagation System, MDPI Applied Sciences

Introduction

Objectives:

- Determine if daughter plant size affects rooting success
- Determine rooting differences between daughter plant sizes

Hypothesis:

Daughter plant size will affect root development but will not rooting success rate

Materials and Methods

- Crown diameter
- Root number
- Leaf number
- Fresh mass
- Position on the stolon
- Leaf size (area or length)
- Stolon diameter
- "Greenness"

Materials and Methods

- **Crown diameter**
- Root number
- Leaf number
- Fresh mass
- Position on the stolon
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Materials and Methods

- **Crown diameter**
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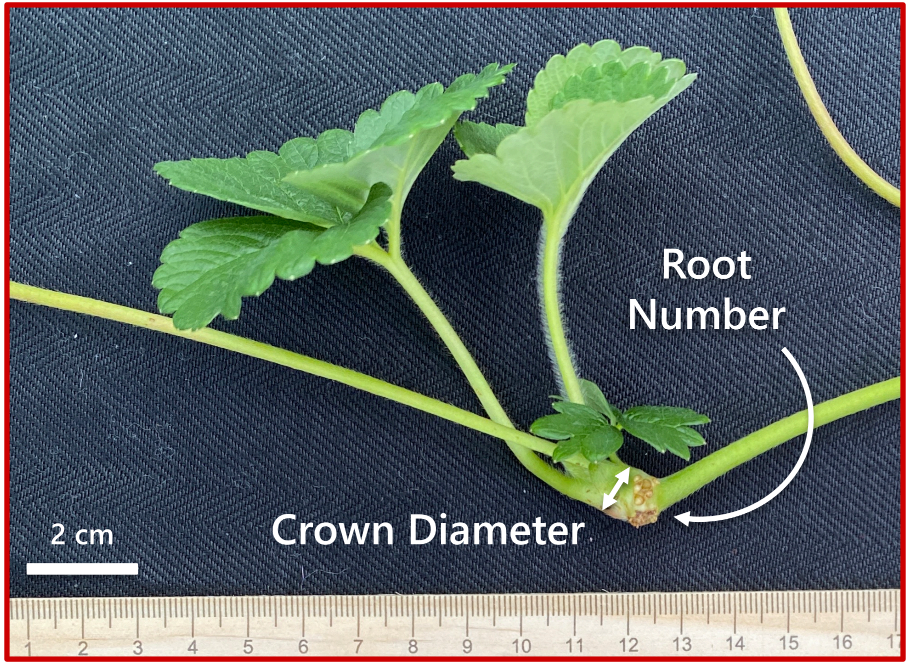


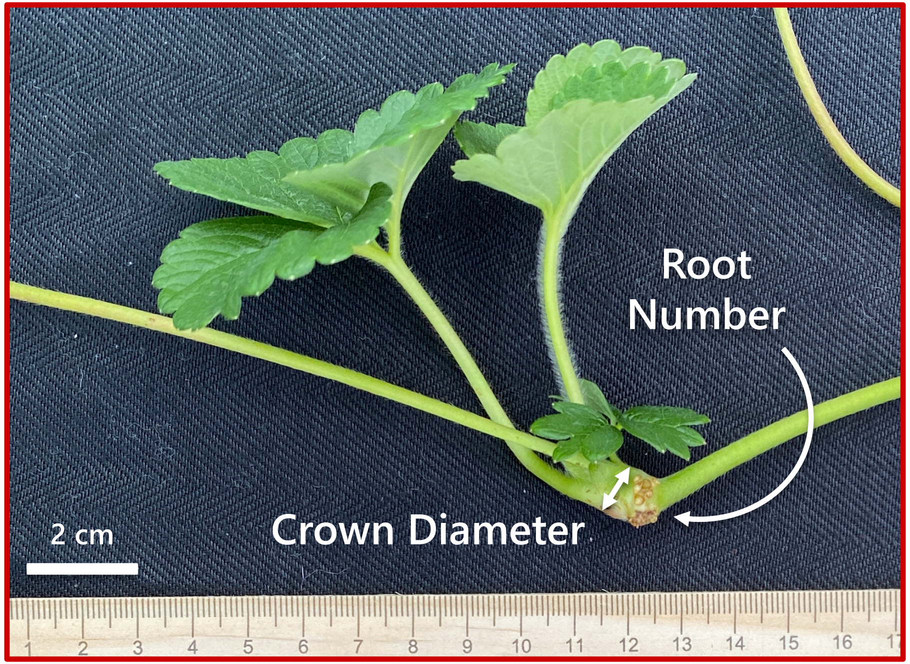
Materials and Methods

Very Small (VSM)

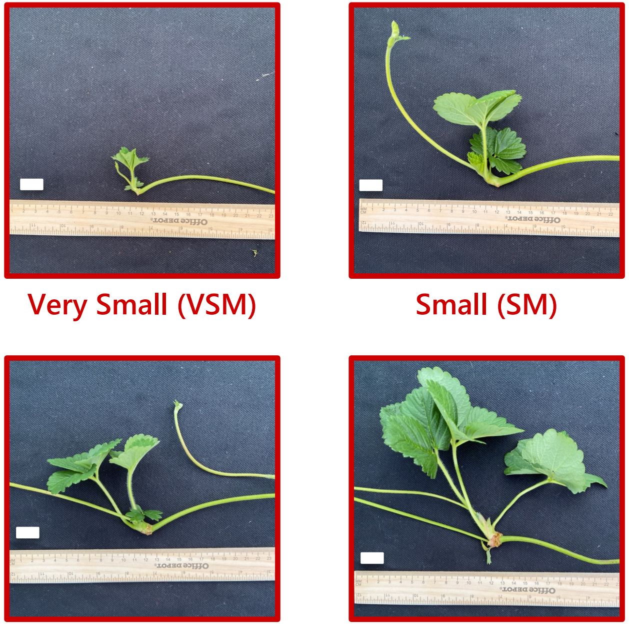
Small (SM)

Medium (M)

Large (L)



Materials and Methods

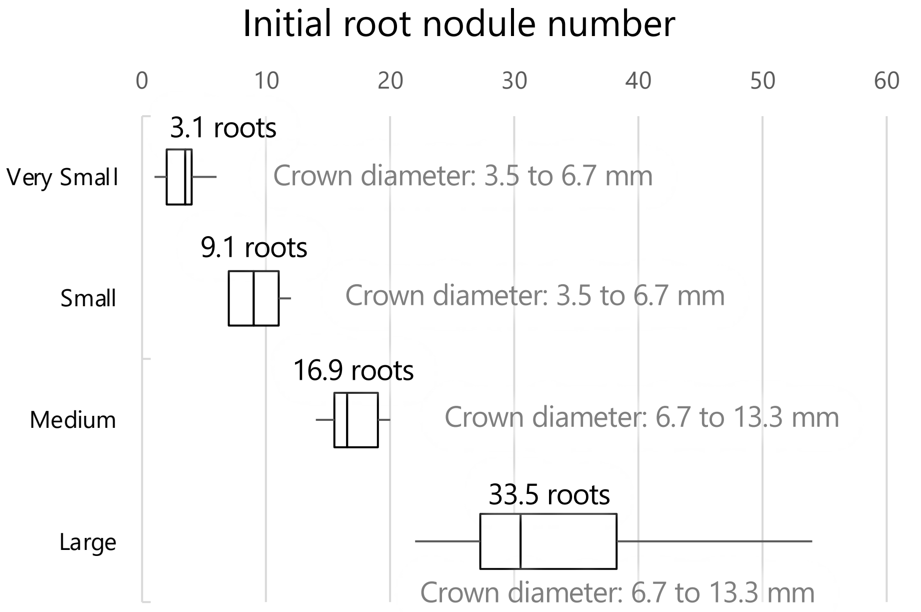


Very Small (VSM)

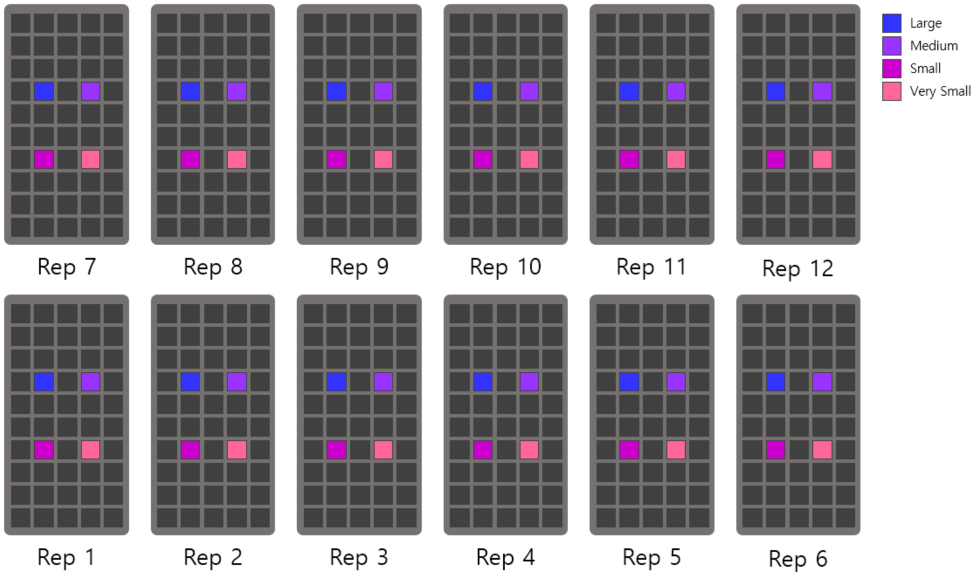
Small (SM)

Medium (M)

Large (L)



Materials and Methods



Materials and Methods

- Cultivar: Monterey
- Randomized complete block design
- n = 12, where n = 1 plant

Variable	Value
Duration	28 days
Temperature	24.2 ± 1.3 °C
Relative Humidity	99.3±2.2%, lowered to 91.6±3.5%
Vapor Pressure Deficit	0.02±0.06 kPa, raised to 0.24±0.09 kPa
Photoperiod	18h
Light intensity (PPFD)	80.3±0.9 µmol m^{-2} s^{-1} (30B:70R)
CO2 concentration	470±73
pH	5.8
EC	2.1
Nutrients	Custom nutrient solution

Materials and Methods

https://docs.google.com/spreadsheets/d/1A0JTtLbf3jGzdnU8Ry34rKbMjaoYEe5VcsEpXJxoKAI/edit?usp=sharing

Growing Conditions

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D26

	A	B	C	D	E
1			Young plants	Propagative mother plants	
2	Parameter	Units	Humphrey tip size experiment, Monterey plug plants	Humphrey stock plants, Monterey and Fronteras	Humphrey CO2 experi Monterey and Fronte
3	Light intensity (canopy level)	PPF, µmol mol-1 s-1	80	400	200 or 400
4	Photoperiod	hours	18	18	To be decided
5	Light spectrum	RGB %	30B:70R LEDs	8B:15G:77R (Arize Lynk2 PKR)	25B:38G:37R (Arize Lynk2 B
6	Temperature (air)	degrees C (day/night)	25 setpoint (24.2 ± 1.3)	25/25	To be decided
7	Temperature (liquid culture)	degrees C	N/A	N/A	N/A
8	Relative Humidity	%	99%, lowered to 90% on day 20	~50%	To be decided
9	Carbon dioxide	µmol mol-1 (=ppm)	400 setpoint (470 ± 73)	400	400 or 700 or 1200
10	Air velocity	m s-1	<0.1	0.5 to 1	To be decided
11	Watering	L	As needed, watered over top (depend	As needed to maintain soil moisture	As needed to maintain soil m
12	pH	pH	5.8	5.5 to 6	5.5 to 6
13	EC	S m-1	2.1	<1	<1
14	Nutrition (solid media)	mol kg-1 (dry)	N/A	N/A	N/A
15	Nutrition (liquid culture)	mmol L-1	Custom mix based on tomato	Custom mix based on tomato for the f	To be decided
16	Substrate type		70:30 coconut coir:perlite by volume	Sungro MetroMix	To be decided
17	Container volume	L	~76 mL	~3 L	To be decided
18	Room/chamber specifications	Floor area and model	2.7x1.2 m custom chamber	2.7x1.2 m custom chamber	1.3x2.8 m chamber
19	Barrier beneath lamps		>3 mm thick transparent acrylic	None	None
20	Airflow	up, down, or horizontal	Horizontal	Down	To be decided
21	Notes		NO misting (unlike common strawberry rooting systems), instead we maintained very high humidity; duration of this experiment was 28 days		Treatments for light intensity CO2
22					

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Materials and Methods

- Crown diameter
- Visual root assessment
- Shoot and root fresh and dry mass
- Water and nitrogen consumption
- Number of leaves
- Longest leaf length
- Plant height
- SPAD chlorophyll content
- Leaf area
- Gas exchange and transpiration

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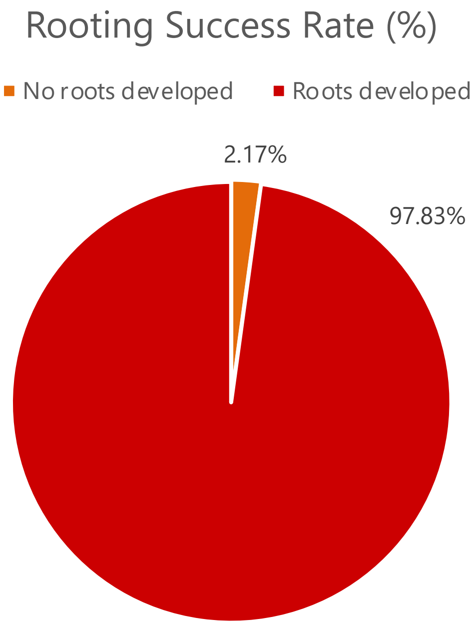
Results: Rooting Success



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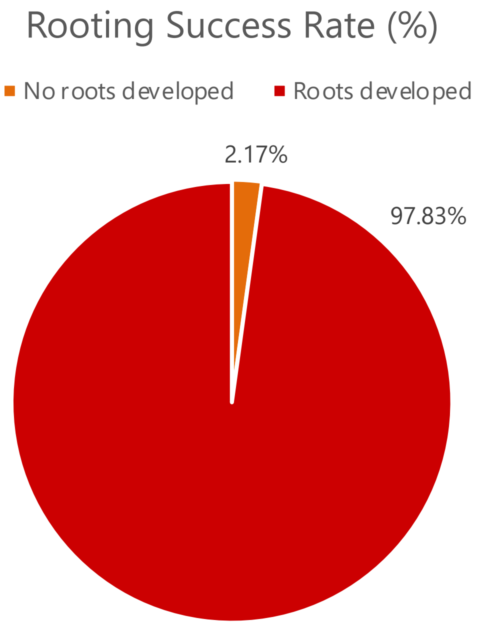

Photo courtesy: Shi, et al. 2021: Timing of Stolon Removal Alters Daughter Plant Production and Quality in the Ever-bearing Strawberry ‘Albion’, HortScience

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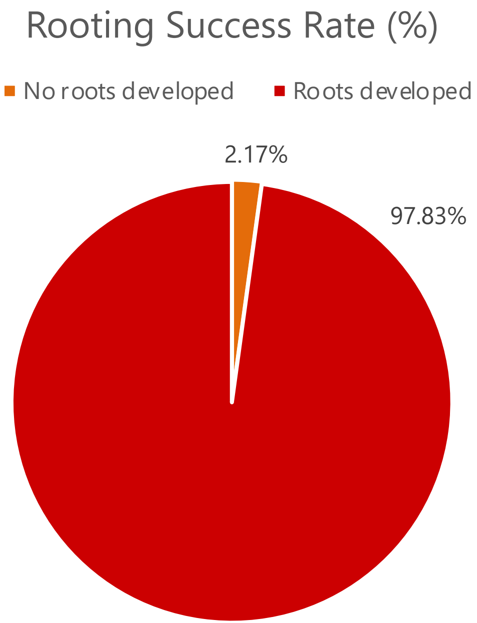

Hypothesis:
Initial size will not affect rooting success

Photo courtesy: Shi, et al. 2021: Timing of Stolon Removal Alters Daughter Plant Production and Quality in the Ever-bearing Strawberry 'Albion', HortScience

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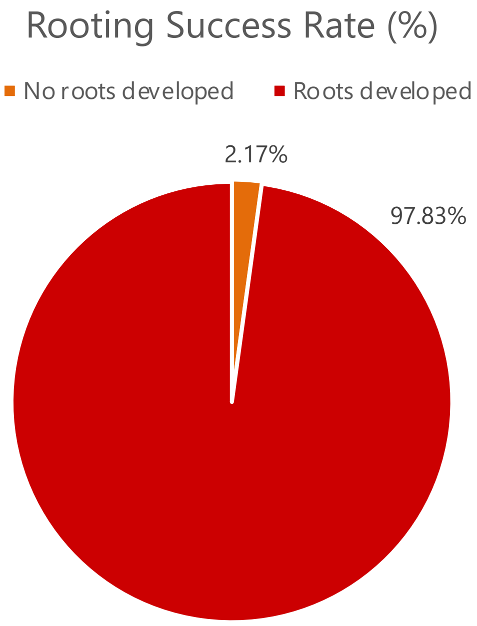
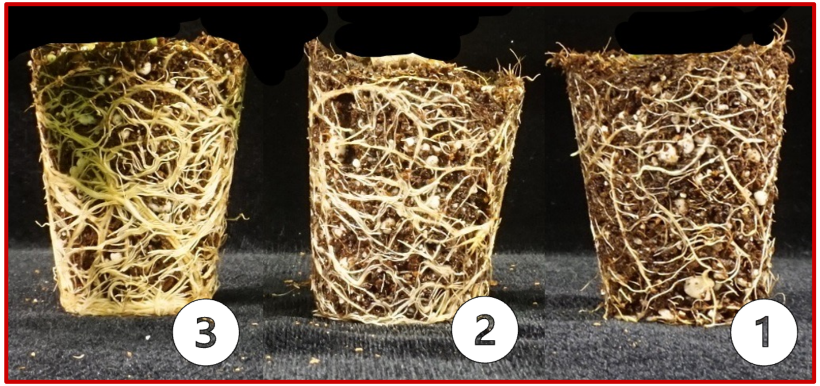


Hypothesis:
Initial size will not affect rooting success

Finding #1:
We can root all sizes of daughter plants in controlled environments

Photo courtesy: Shi, et al. 2021: Timing of Stolon Removal Alters Daughter Plant Production and Quality in the Ever-bearing Strawberry 'Albion', HortScience

Results: Growth Differences



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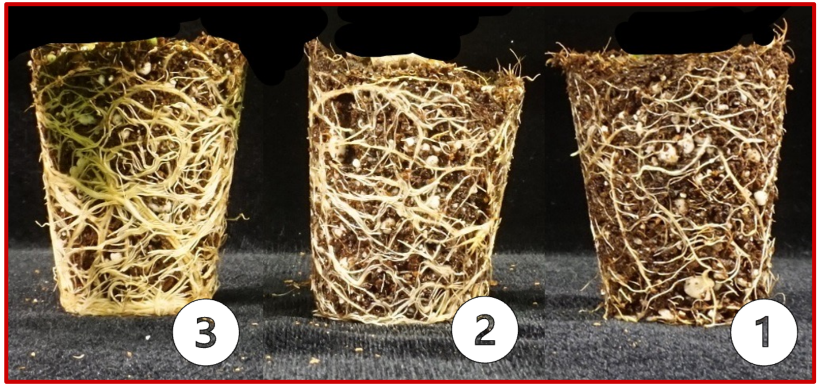

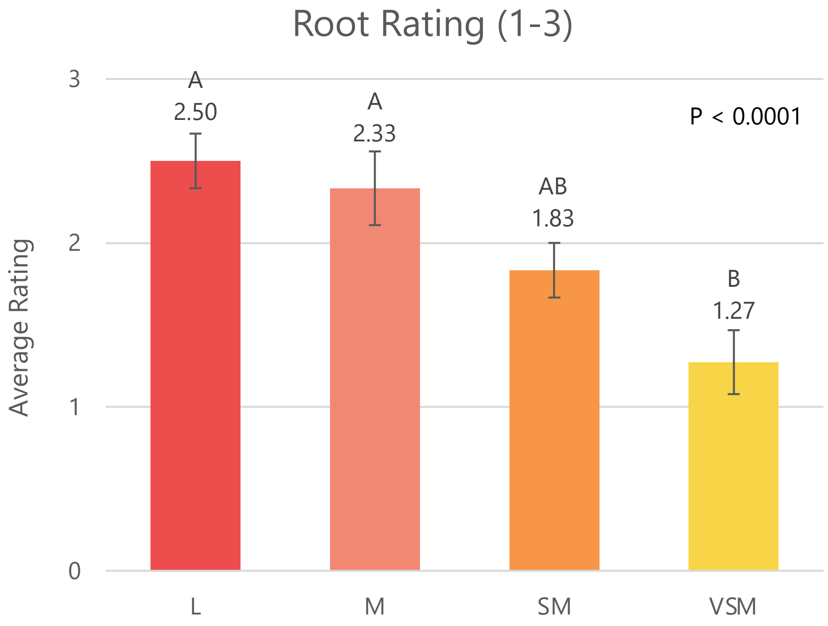

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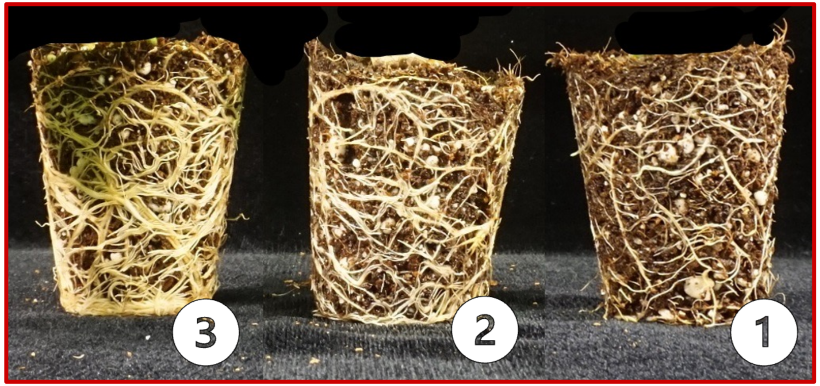
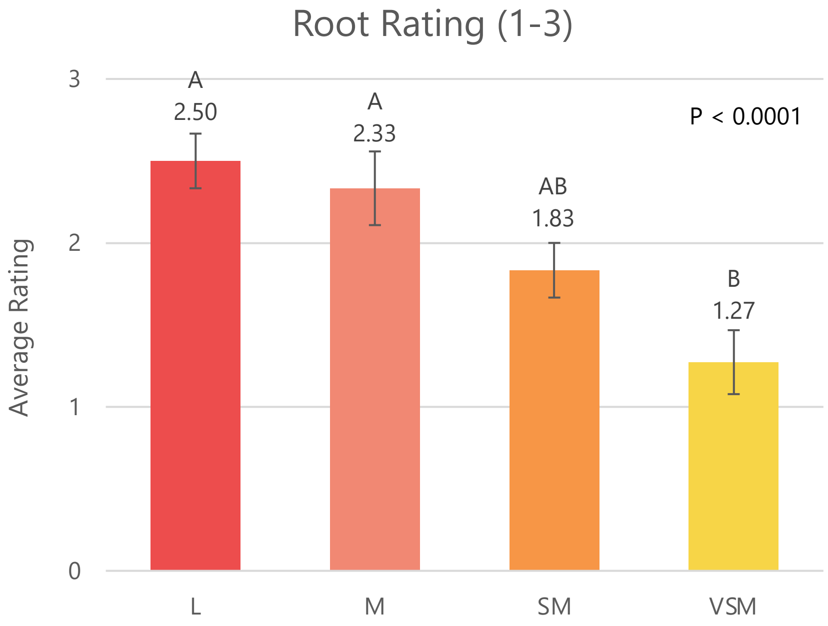
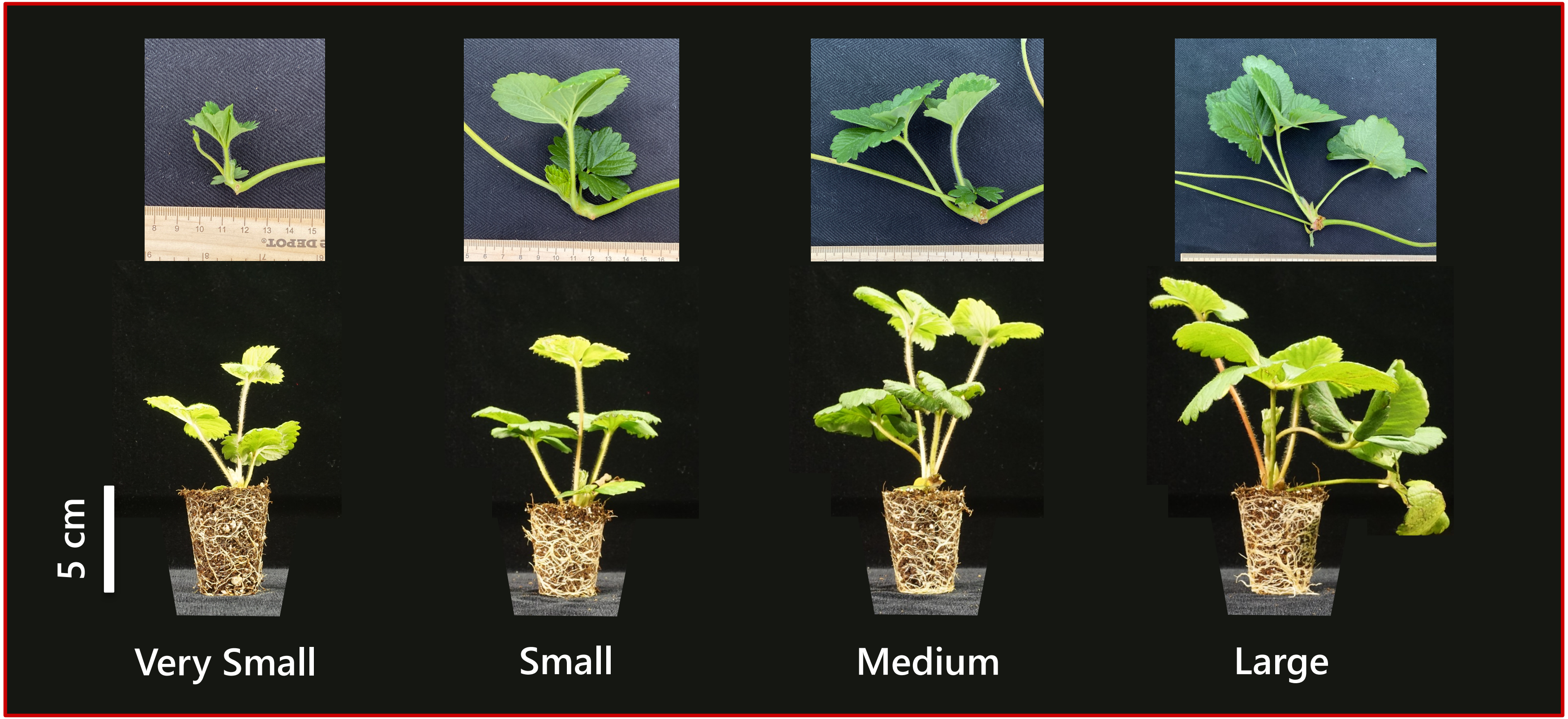
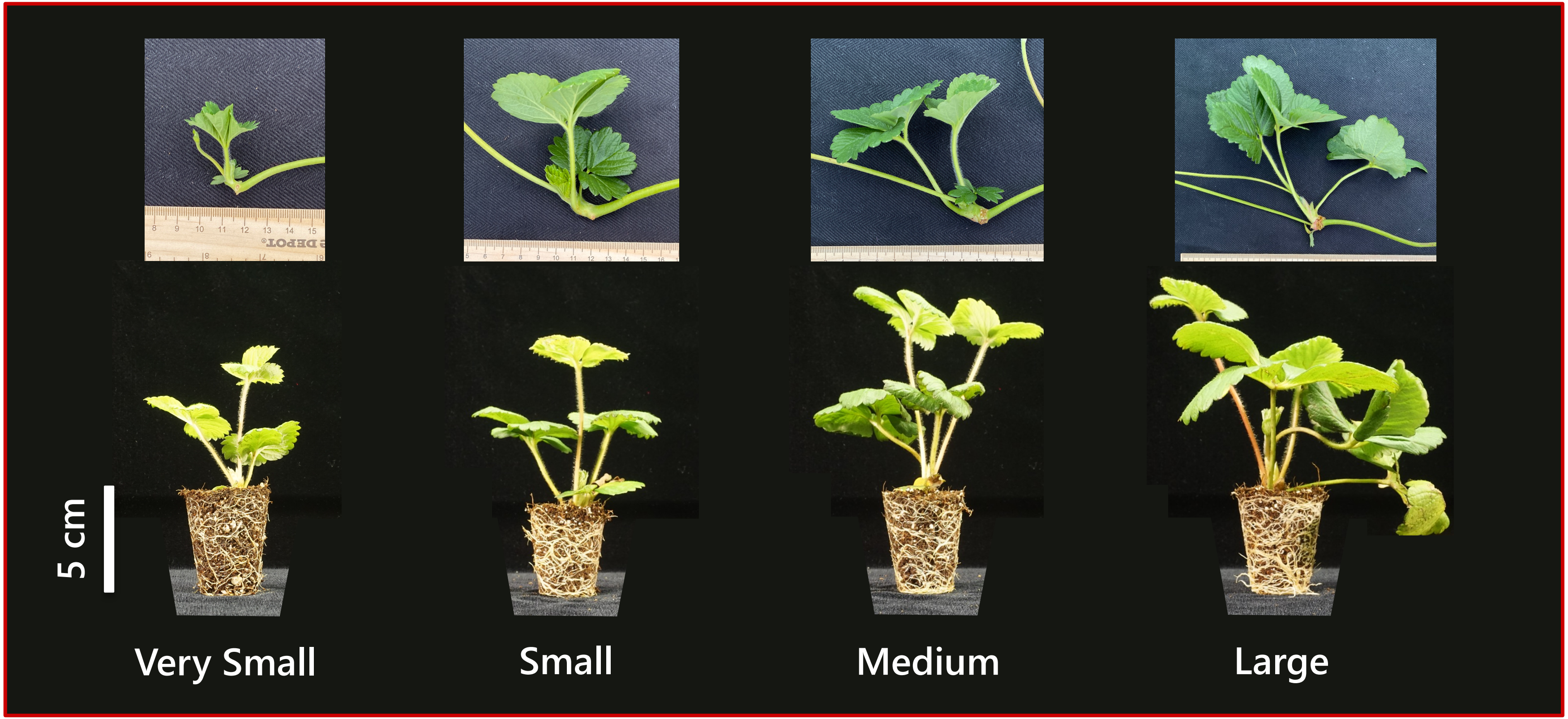





5 cm
Very Small
Small
Medium
Large



Finding #2: Larger size before rooting is correlated with larger size after rooting

Results: Relative Growth Rate

$$\left(\frac{final - initial}{initial}\right)100$$

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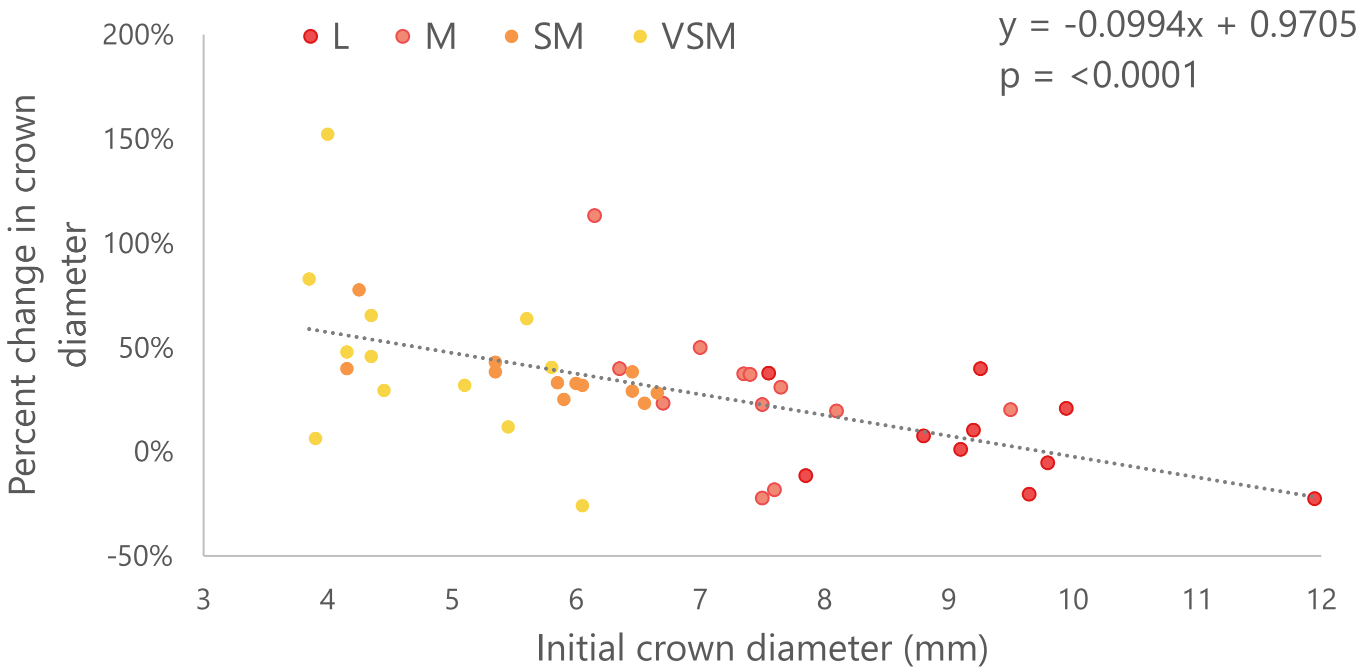

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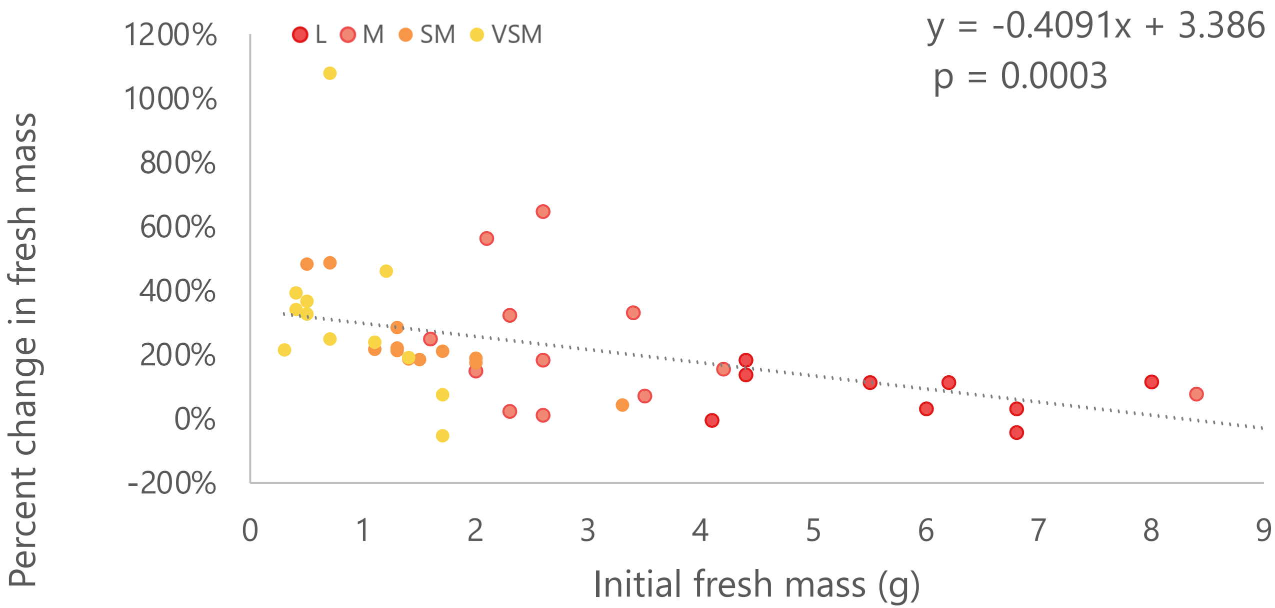

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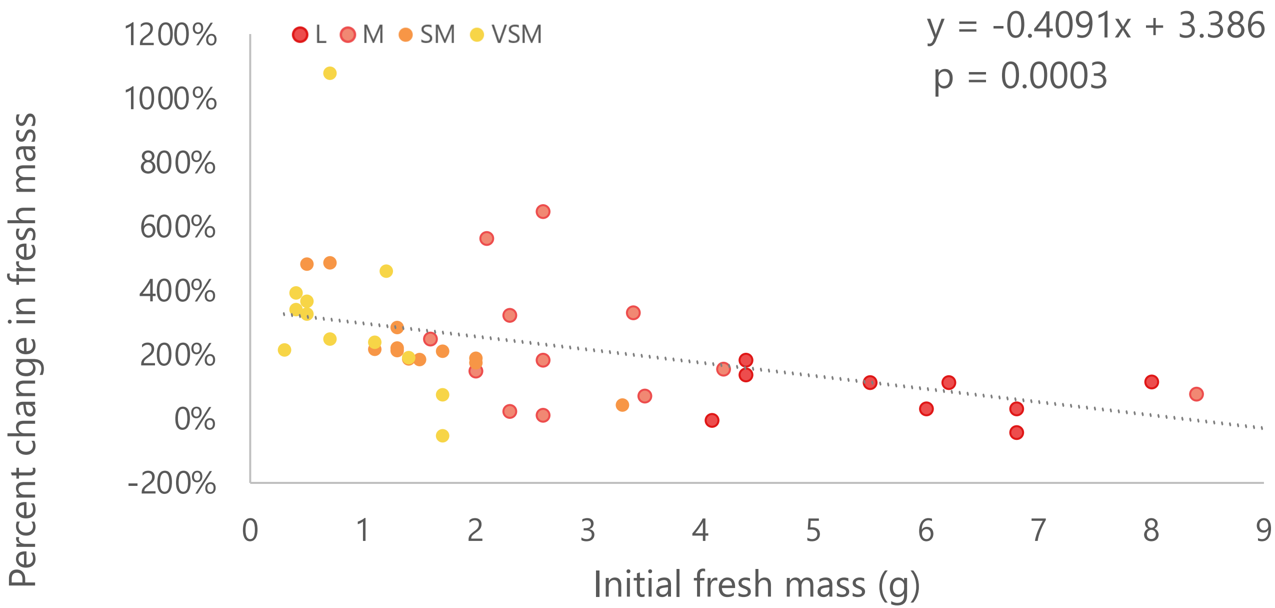

Finding #3: Growth rate varies depending on initial plant size

Main Conclusions

#1: We can root all sizes of daughter plants

#2: Final size is correlated with initial size

#3: We can predict growth rate based on initial size

Future Work: Field Trials!

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  - Potentially similar plant growth in the field, despite plug plant size (Hokanson, 2002; Bish, 2000)

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Can we use small daughters to grow the same quality of fruiting plants?

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Acknowledgements

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Jerry Yu
Emma Volk

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United States Department of Agriculture
National Institute of Food and Agriculture

UNIVERSITY OF MARYLAND

PIP CAP

Precise Indoor Propagation

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/

Progress in identifying DNA variants associated with runnering and flowering traits in strawberries

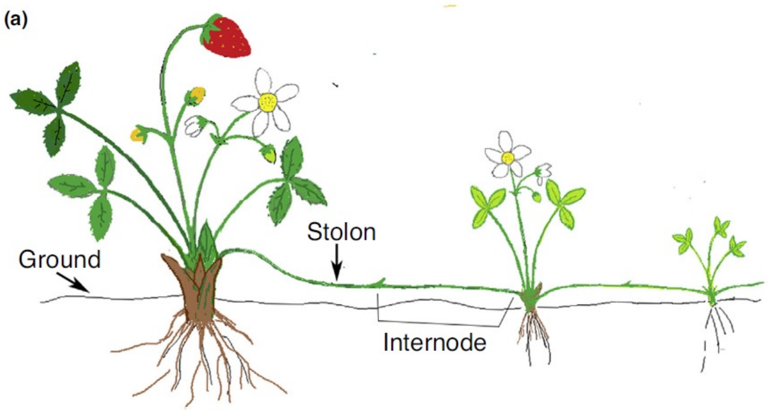
Xi Luo, Ph. D.

Genetics Team @ University of Maryland

PI: Dr. Zhongchi Liu

8.24.2022

Cultivated strawberries (*F. × ananassa*) are propagated by runners



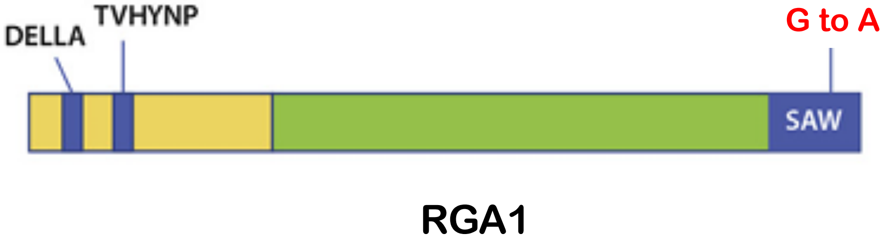
Guo et al. 2021, Current Opinions in Plant Biology

Photo credit: Ruud Morijn

Genetics is powerful!

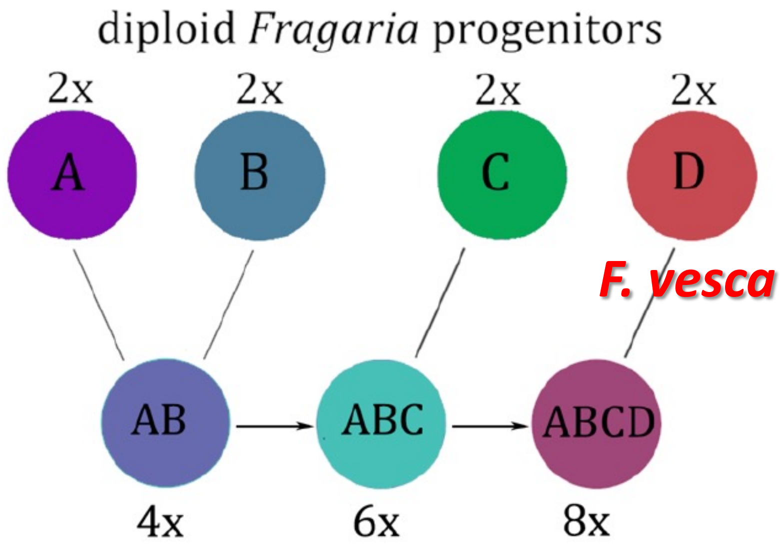
Caruana et al. 2018

One nucleotide change = runner or not



The genes regulate runner and flowering traits in *F. vesca* could be applied to cultivated strawberries

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



Edger et al. 2019

Hypothesis

1. Genetic variations in the key genes in cultivated strawberries may be correlated with their flowering or runnering phenotypic response to the environment

2. By identifying those correlation, propagation capacities of cultivated strawberries could be predicted

The 12 cultivars included in the analysis

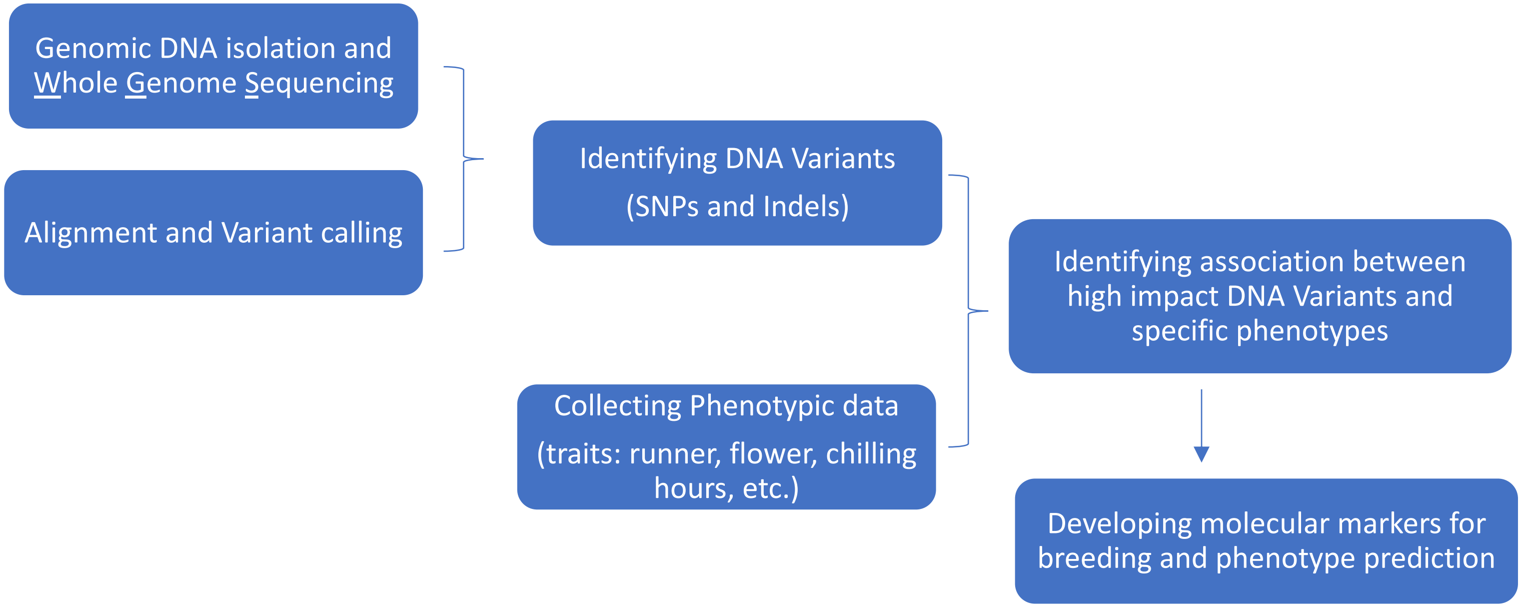
June bearing (seasonal flowering)

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

Everbearing (perpetual flowering)

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

Analysis pipeline



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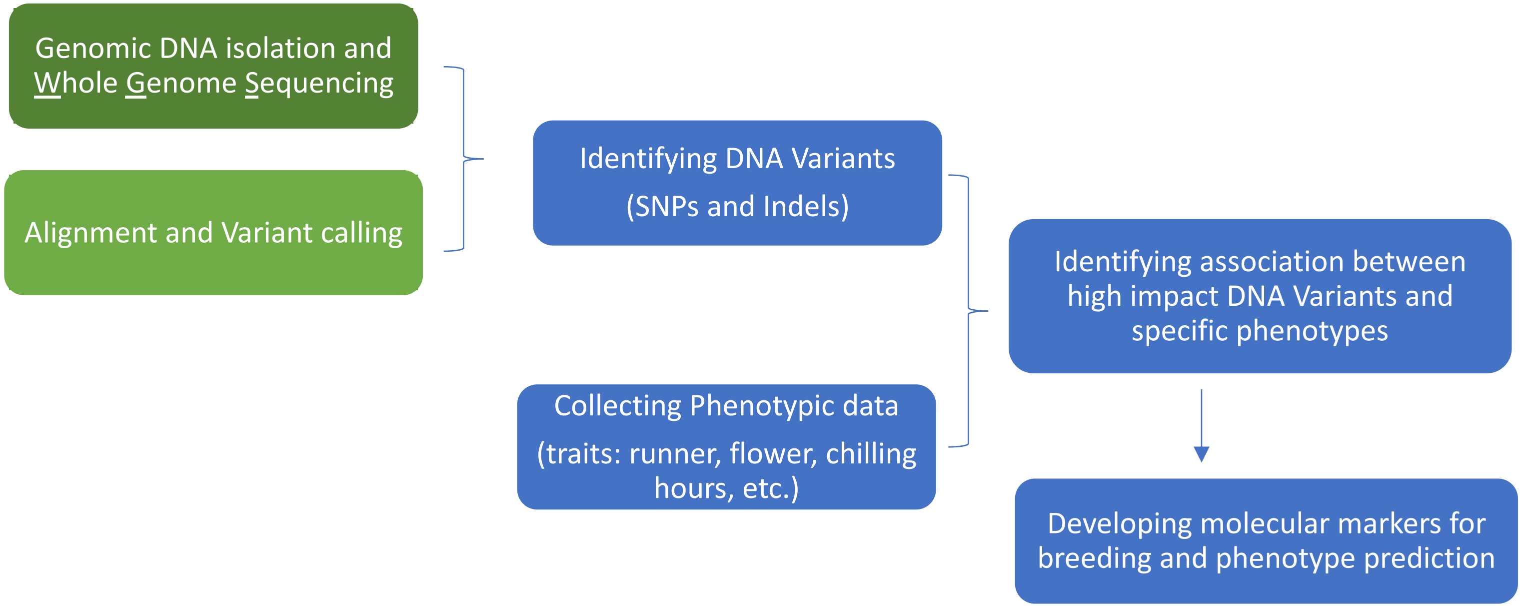


Whole genome sequencing data summary

	• Reads (Million)	Bases (Billion)	Q30 bases (%)
Albion	246.45	36.81	94.17%
Brilliance	205.10	30.62	93.87%
Cabrillo	222.13	33.14	93.75%
Camarosa	214.25	32.00	93.42%
Chandler	214.03	31.94	93.44%
Finn	225.94	33.72	93.61%
Fronteras	233.60	34.89	93.61%
Monterey	224.13	33.48	93.62%
Moxie	204.68	30.56	94.10%
Portola	210.50	31.41	93.44%
Radiance	223.81	33.44	94.13%
Ruby June	214.21	32.01	93.94%

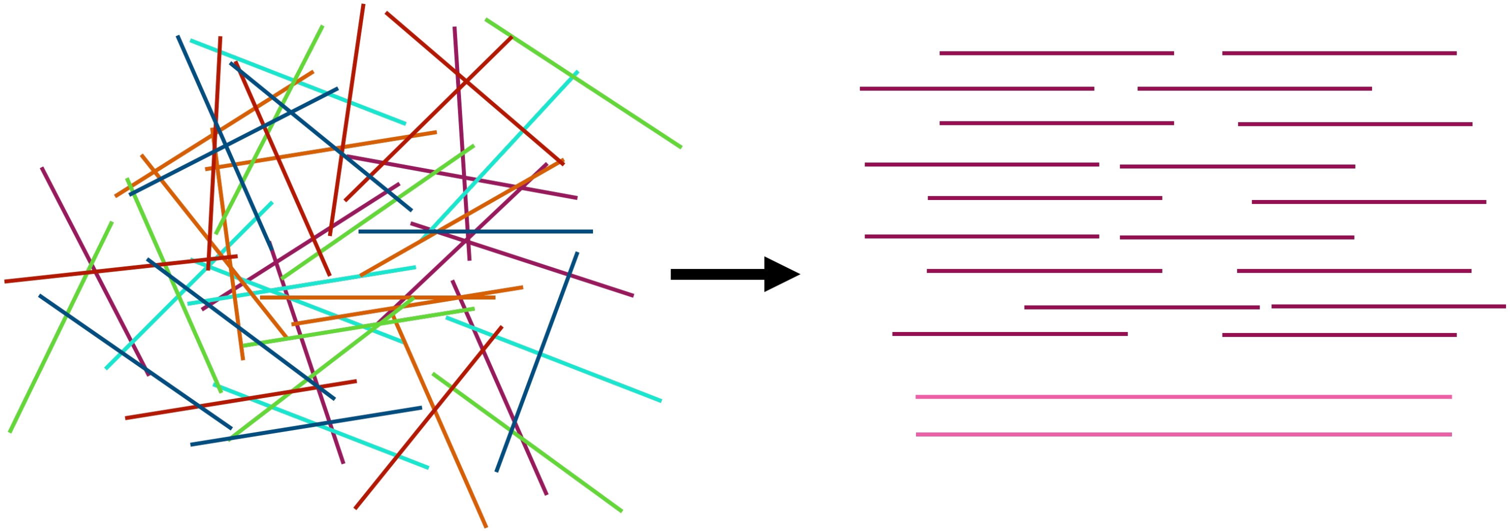
- ~ 35 billion bases each cultivar
- High quality: Q30 bases >93%
- 145X coverage on average

Note: Q30 means the sequence error rate is 1/1000 bases

Aligning sequences to reference genome

Sequencing reads are disorganized

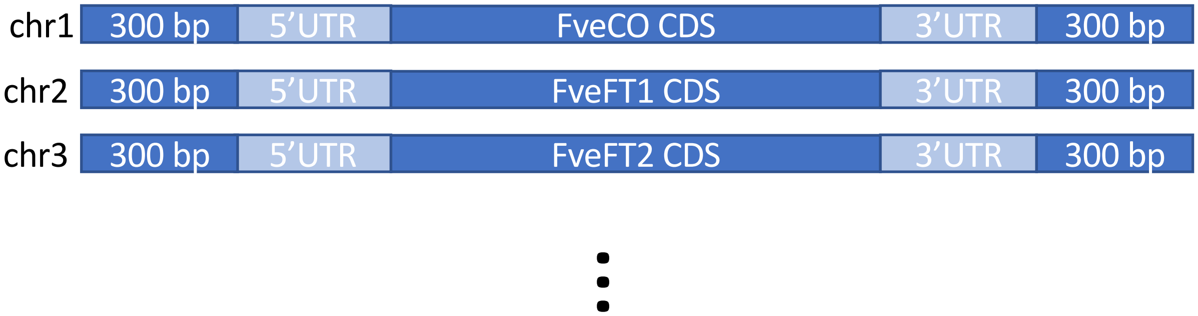
Sequencing reads are matched or “aligned” to reference genome



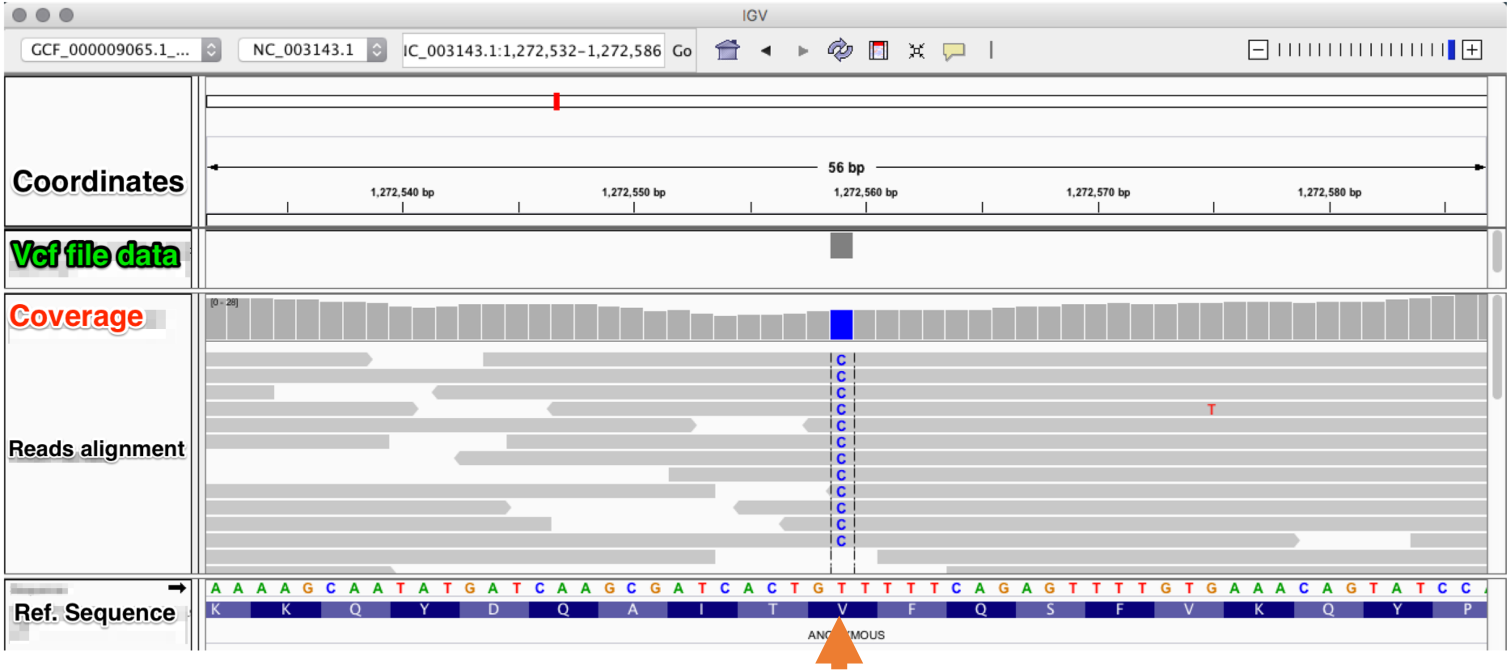
Reference genome

Synthetic reference genome

Our reference genome composed of all of our genes of interest from the known *Fragaria vesca* genome.



Variant calling: discovering variants in genes from different cultivars



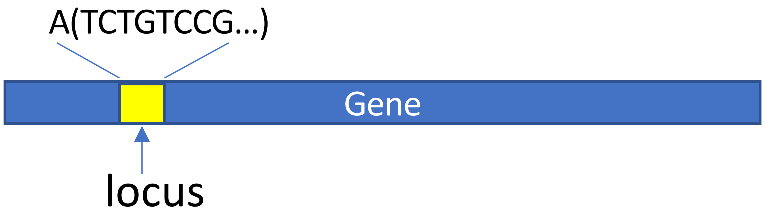
An example:
10 reads coverage

A T-to-C SNP with
100% variant allele
frequency

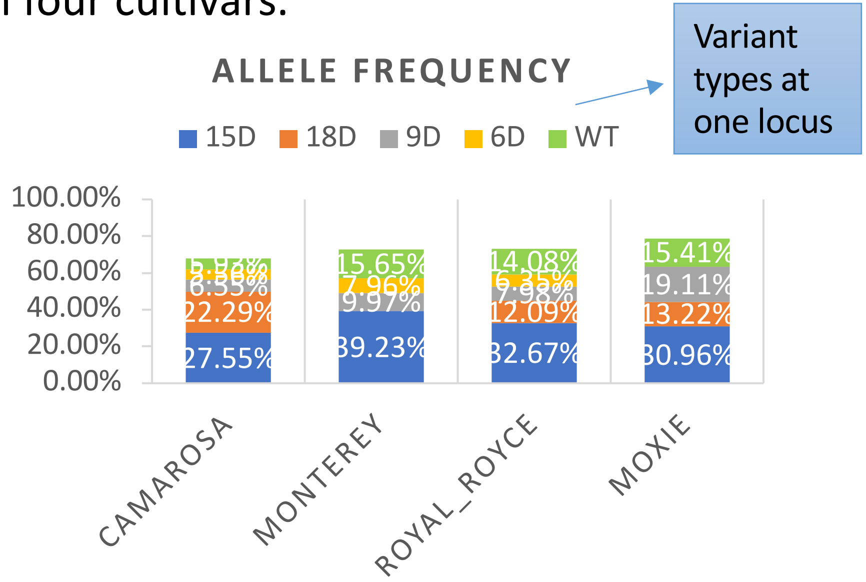
Calculate variant allele frequency

Variant allele frequency:

$$\frac{reads\ harboring\ a\ specific\ variant\ at\ the\ locus}{all\ reads\ aligned\ to\ the\ locus}$$



An example of 4 variant types at one locus in four cultivars.



Future directions:

1. Fully develop a list of phenotypes

- ❖Runner proliferatively or not
- ❖Flowering time
- ❖Vigor
- ❖Refined day length
- ❖Chilling hour requirement

2. Identify association between high impact DNA variants and specific phenotypes

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- Liu lab

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Dr. Muzi Li

Ms. Christina Ippoliti

- Hanna Zeng from Lassen Canyon Nursery, Inc