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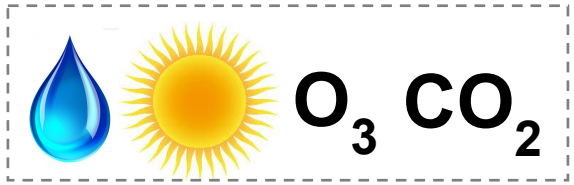
Exploring iridoids blueberry with human health benefits

Courtney Leisner

January 6th, 2023

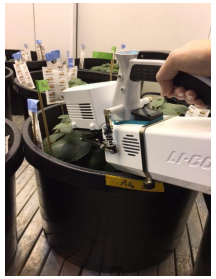
SE Regional Fruit and Vegetable Conference

Auburn University



Realistic depictions of future climate → ***Specialty crop systems*** → ***Understand climate change impacts on food security***

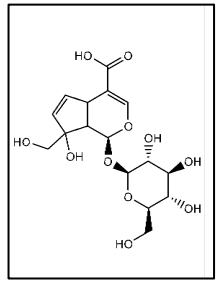
Utilizing integrative research



Physiology

Biomass, Yield

'Omics technologies



Nutritional quality

Enhances our ability to:

Leisner (2020) Plant Science

Genomics-enabled plant physiology

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Blueberry-economically important fruit crop

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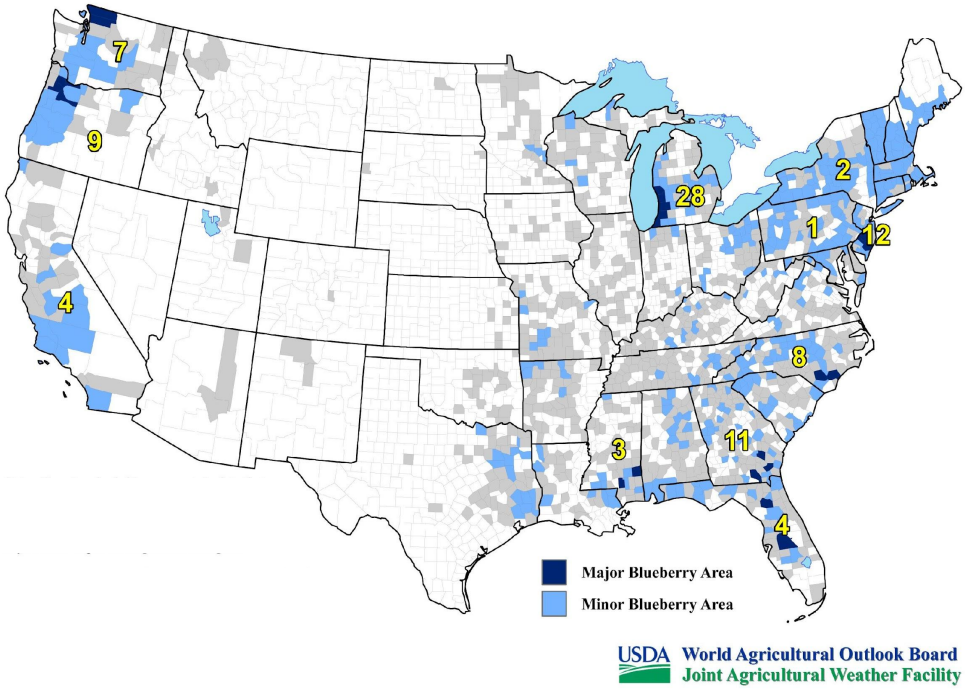
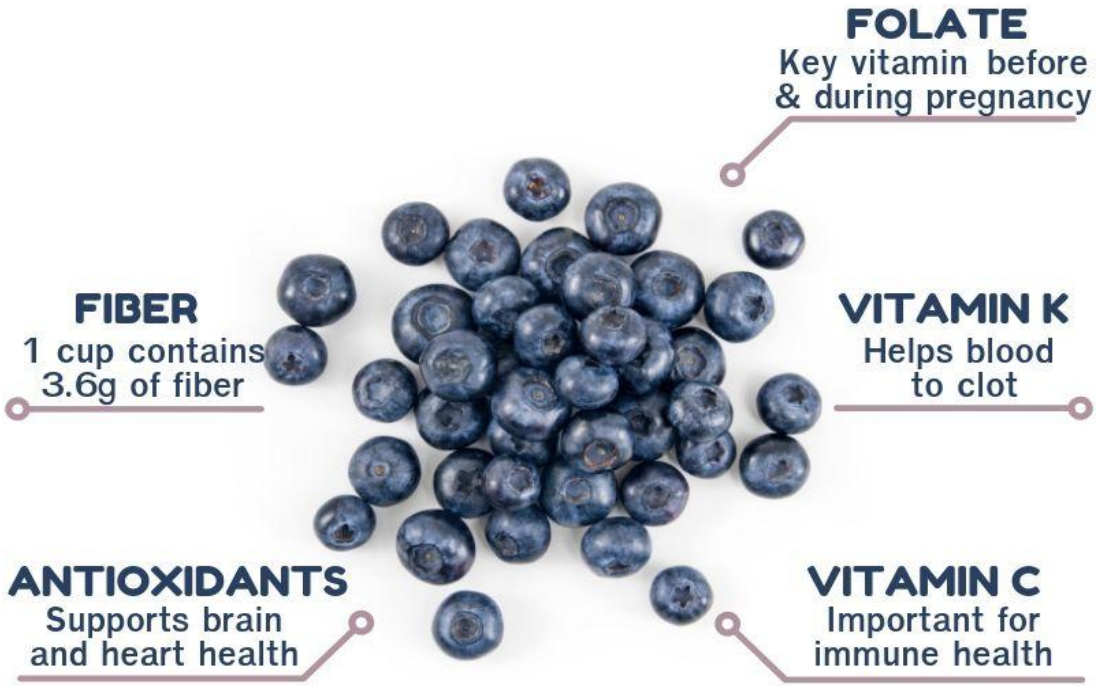
Economic importance



2019: 673 million pounds = $909 million

Human health benefits



Blueberry-economically important fruit crop

Multiple species and ecotypes

ECOTYPE	SPECIES
Northern highbush	***Vaccinium corymbosum***
Southern highbush	*V. corymbosum* with *introgression* of *V. darrowii*
Lowbush	*V. angustifolium*
Rabbiteye	*V. virgatum (*syn. *V. ashei)*

Iridoids-potent natural products

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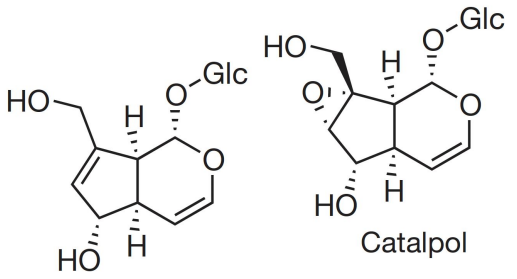
- Iridoids are specialized metabolites present in over 15 plant families
- Iridoids have a wide range of biological activities in humans including anticancer, antibacterial and anti-inflammatory

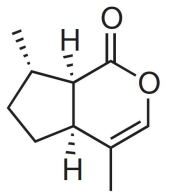
Noni
(*Morinda citrifolia*)

Madagscar periwinkle
(*Catharanthus roseus*)

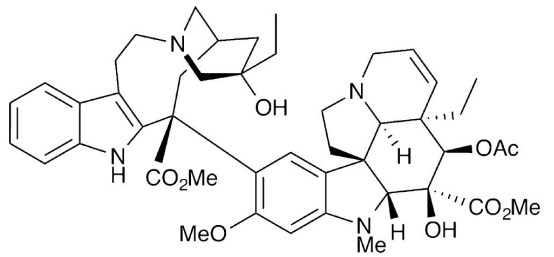


Aucubin

Catalpol



Cis-trans-
nepetalactone



Vinblastine

Geu-Flores et al., (2012) Nature; https://www.jic.ac.uk

Health benefits of the iridoid monotropein

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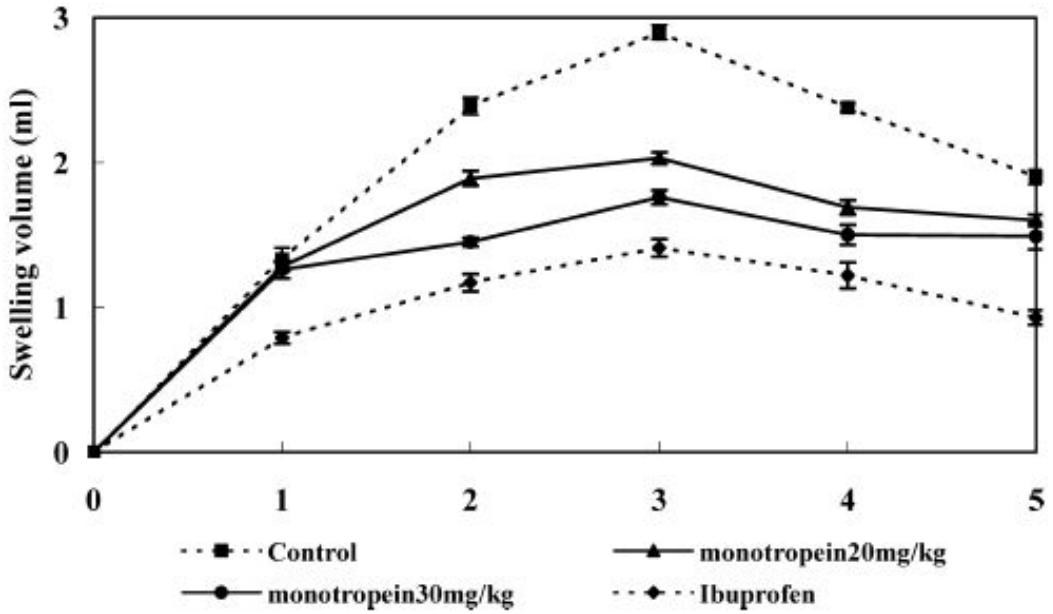
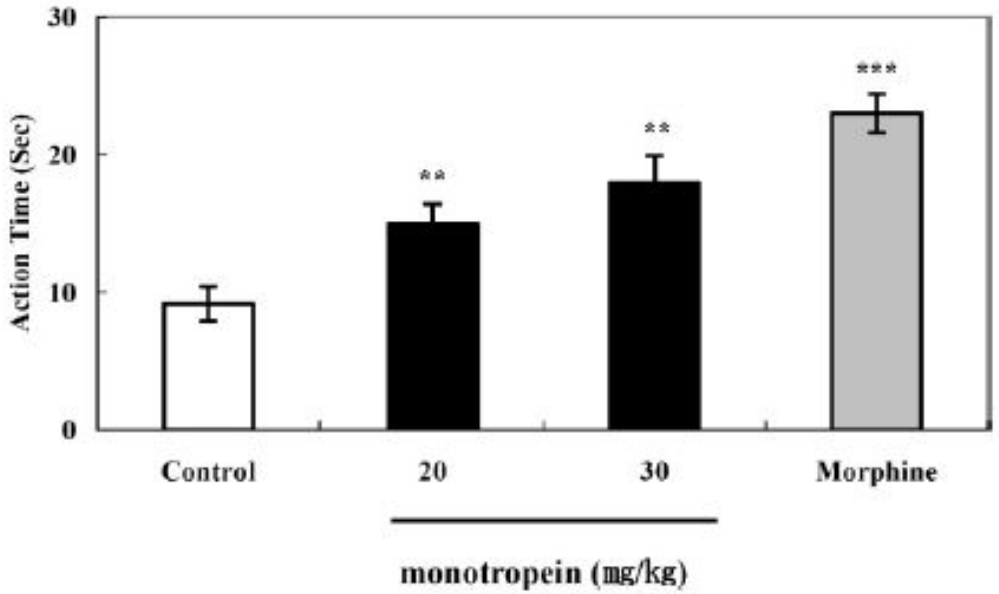
Antinociceptive Anti-inflammatory Effect of Monotropein Isolated from the Root of *Morinda officinalis*





Choi et al. (2005)

Iridoids-potent natural products

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V. myrtillus
(Bilberry)

V. vitis-idaea
(Lingonberry)

V. macrocarpon
(American Cranberry)

V. oxycoccos
(European Cranberry)

V. uliginosum
(Bog bilberry)

V. angustifolium
(Lowbush blueberry)

V. corybosum
(Highbush blueberry)

V. corybosum cv. Briggita

Exploring natural product biosynthesis in blueberry

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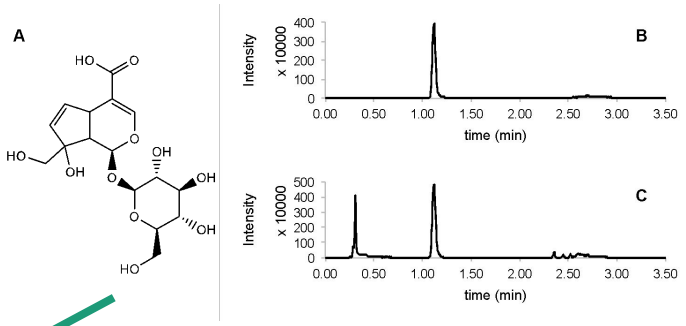
Aim1: Survey iridoid compounds in blueberry diversity panel

71 cultivated blueberries

+

13 wild *Vaccinium* species

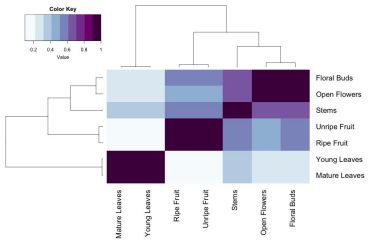
Monotropein



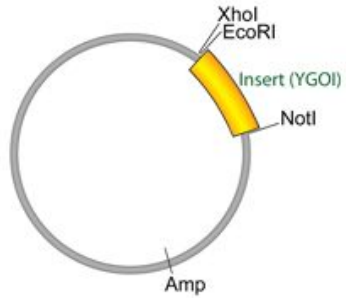
MAX-PLANCK-GESELLSCHAFT

Sarah O'Connor

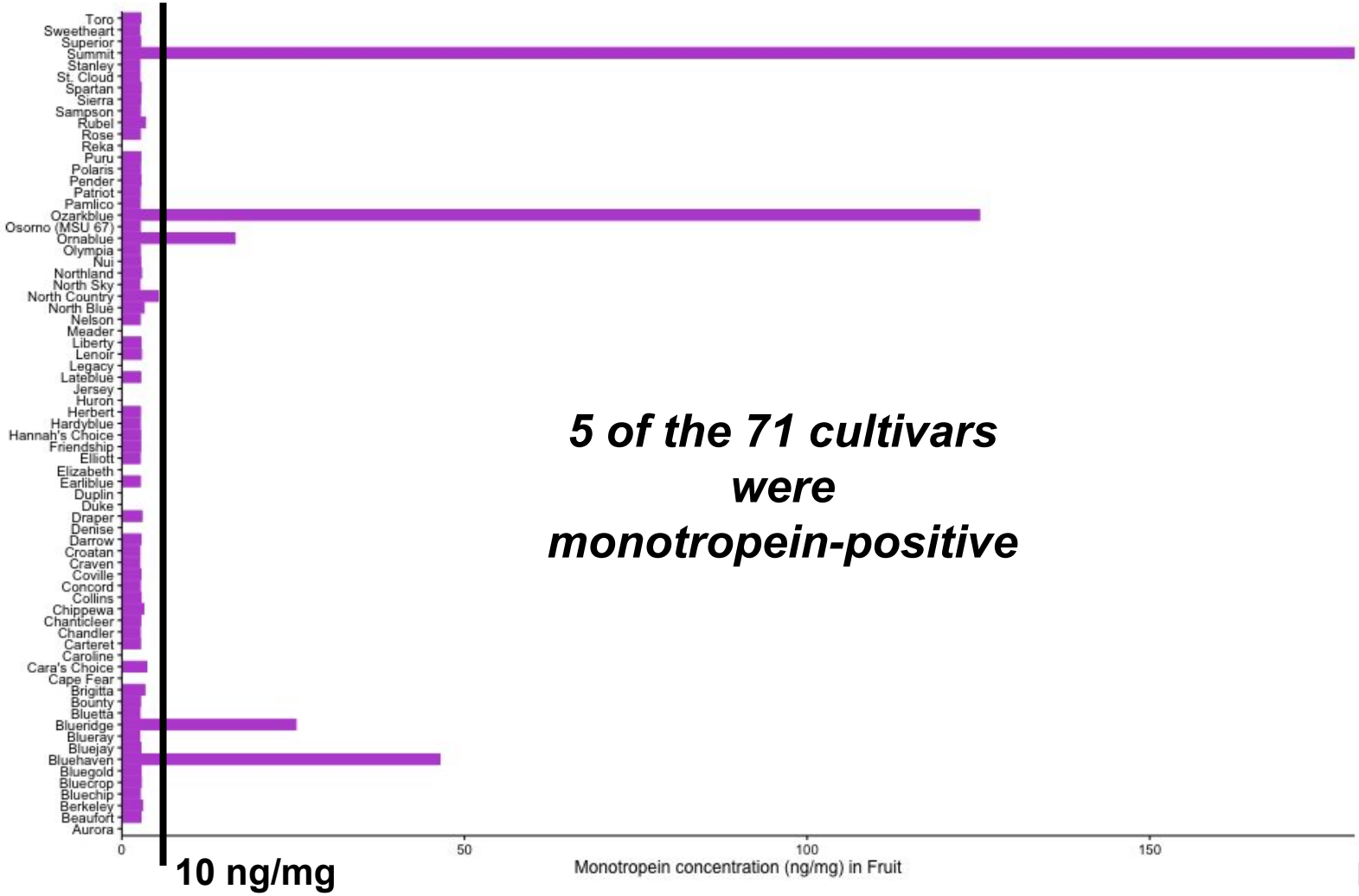
Aim 2: Utilize "omics" approaches to identify iridoid biosynthetic genes in blueberry



Aim 3: Perform functional characterization of key enzymes



Monotropein content in cultivated blueberry

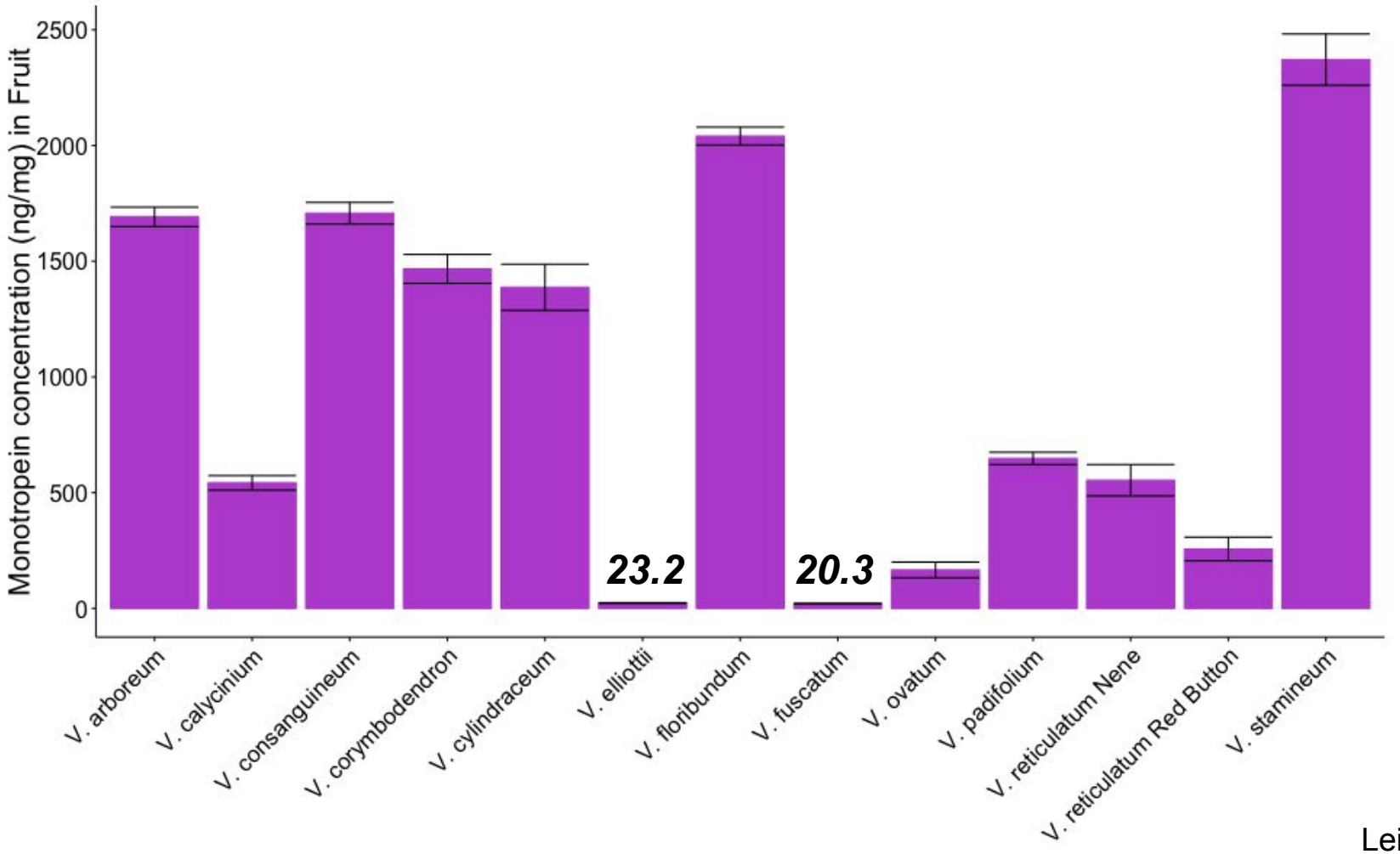


5 of the 71 cultivars were monotropein-positive

Bluehaven (NH)
Blue Ridge (SH)
Ornablue (HH)
Ozarkblue (SH)
Summit (SH)

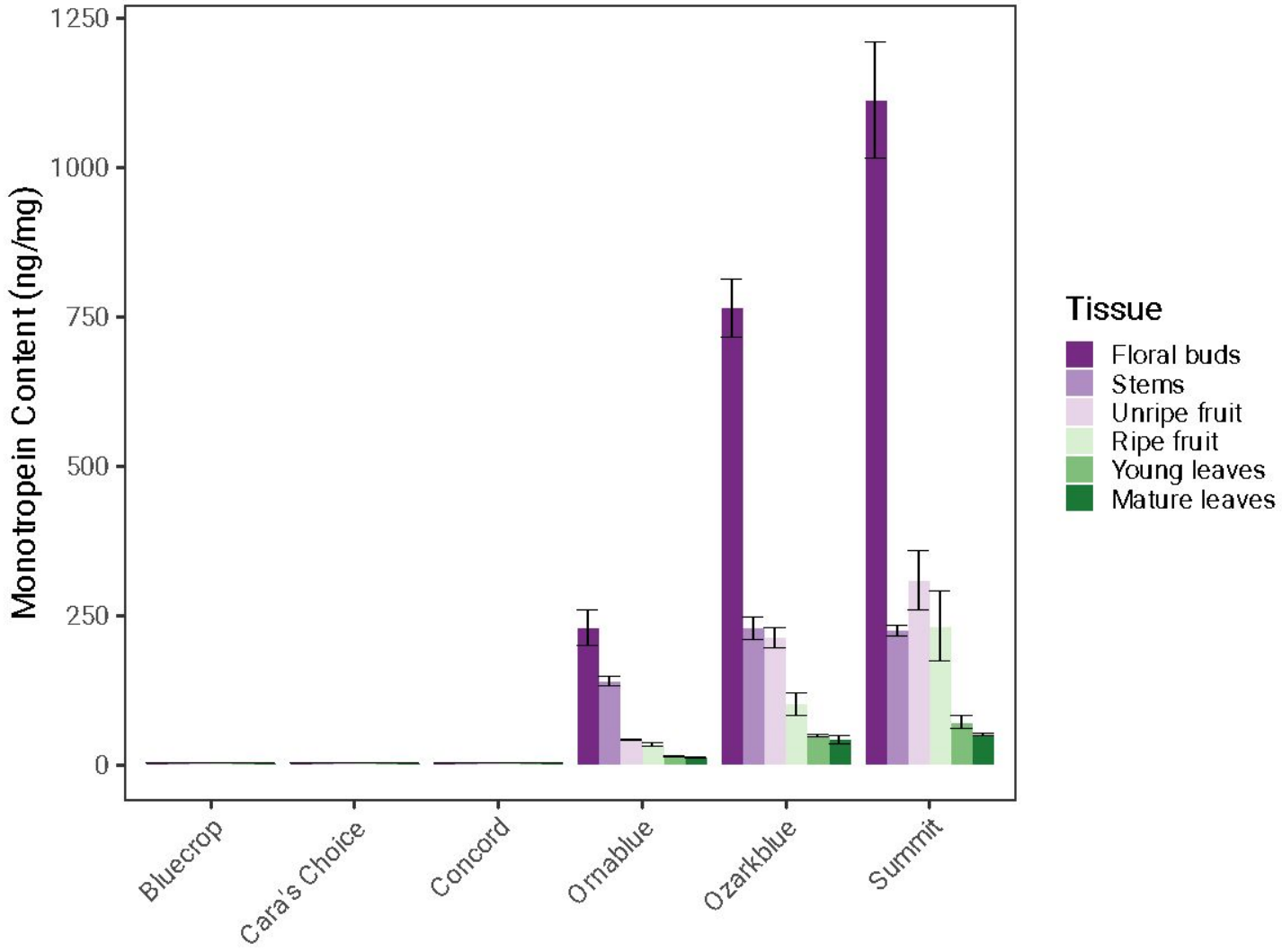
Leisner et al., (2017) PLoSONE

Monotropein content in wild *Vaccinium*



Leisner et al., (2017) PLoSONE

Monotropein content in cultivated blueberry

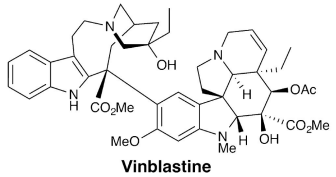


- Presence/absence of monotropein metabolite
- What are the genes involved in the biosynthesis of monotropein in blueberry?

Leisner et al., (2017) PLoSONE

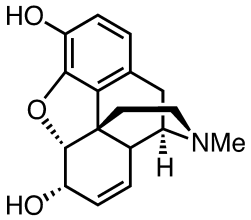
Genetic basis for variation in natural product biosynthesis

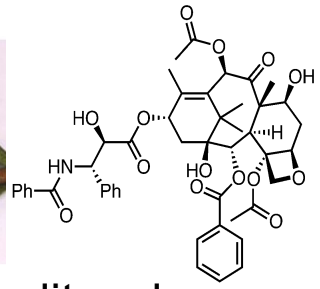
Vinblastine
Catharanthus roseus
cancer



Vinblastine

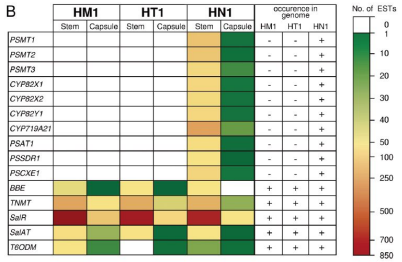
Morphine
Papaver somniferum
pain





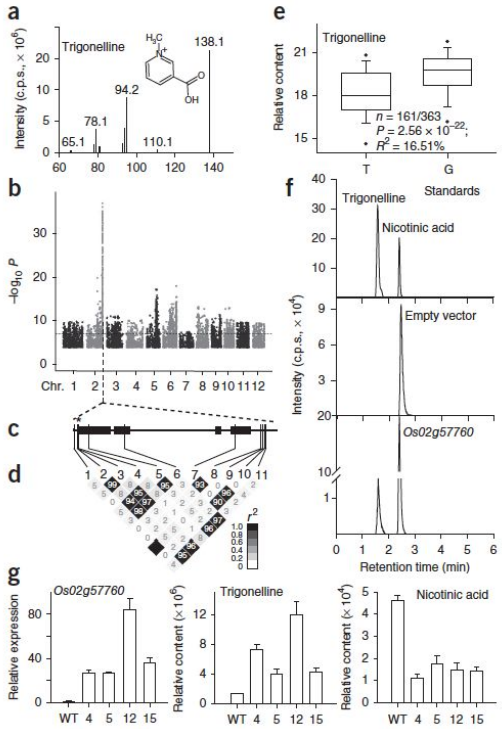
Paclitaxel
(Taxol)
Taxus brevifolia
cancer

Presence/absence variant



Expression

Allelic variation



Chen et al., 2014; Fu et al., 2013; Winzer et al., (2012); https://www.jic.ac.uk

Exploring natural product biosynthesis in blueberry

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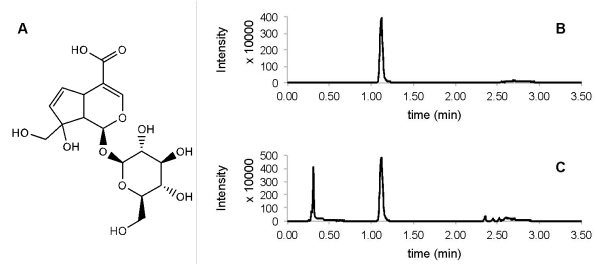
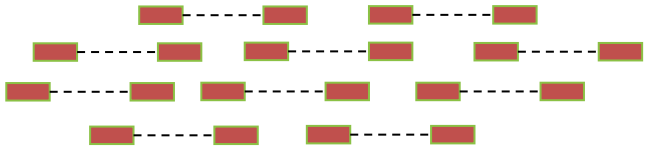
Concord (M-)
Ornablue (M+)

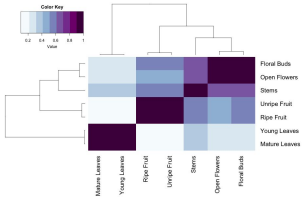
Tissue Series



Transcript Assemblies

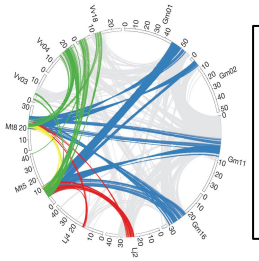


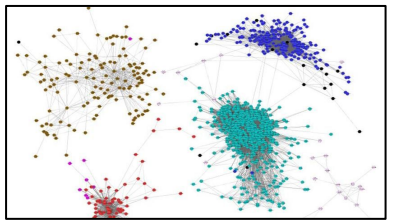
RNA-Seq data



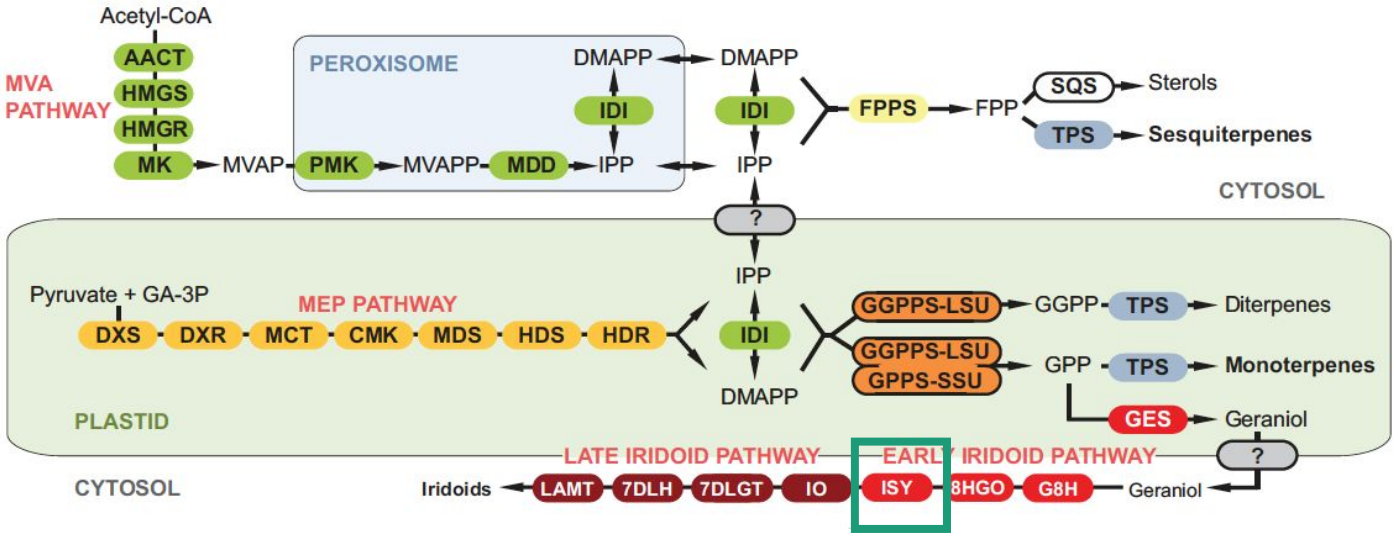
Expression abundances (FPKM)

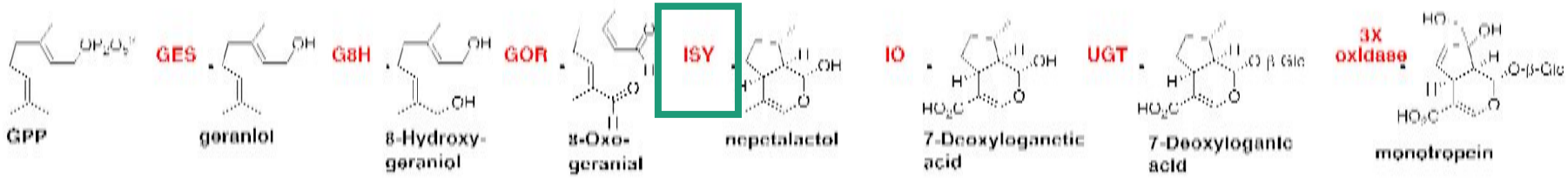
Orthology/ Co-expression





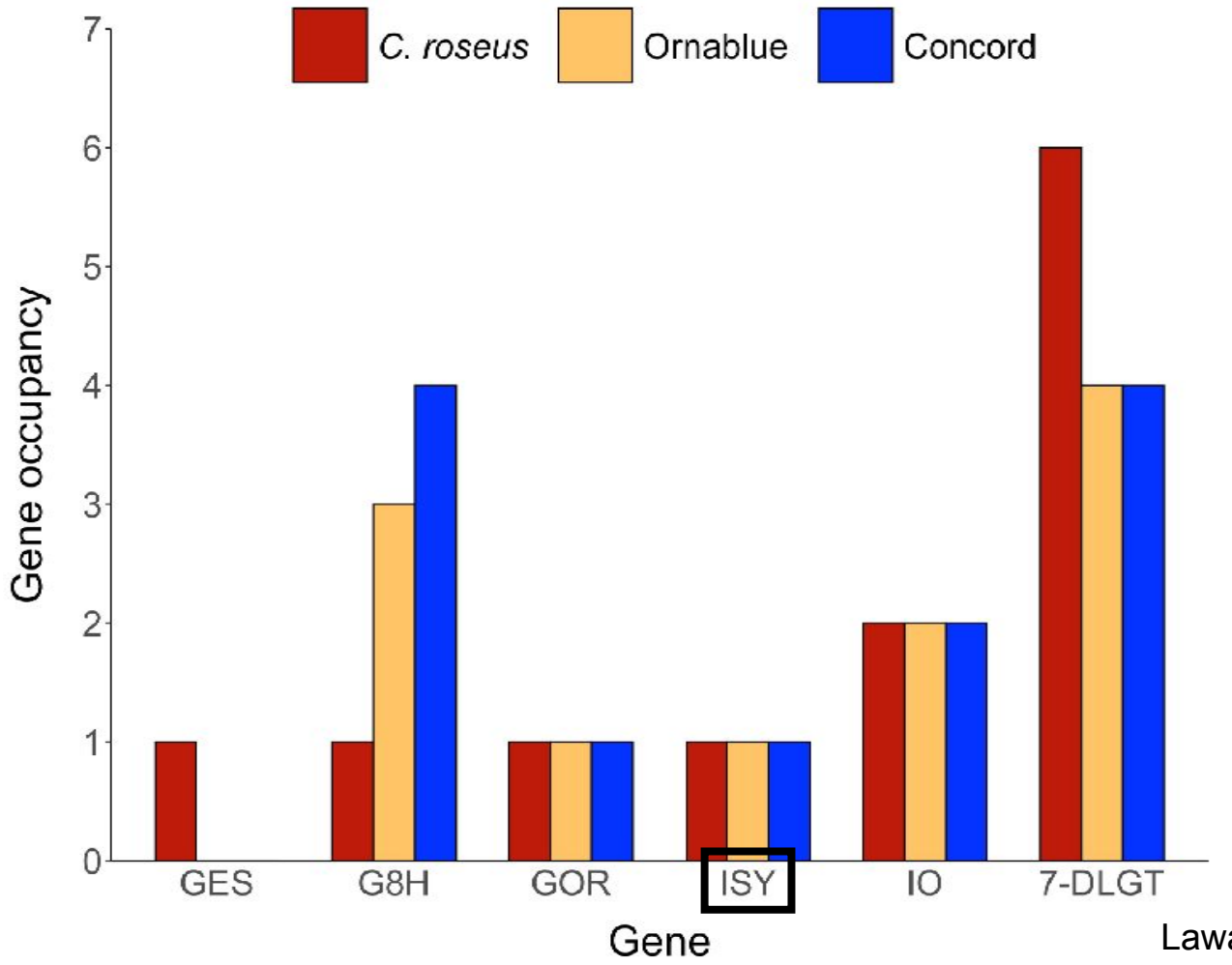
Iridoid biosynthetic pathway





Kellner et al., (2015); Mint Evolutionary Genomics Consortium (2018)

Targeted orthology analysis



Lawas et. al. (*In revision Plant Direct*)

Vaccinium iridoid synthase

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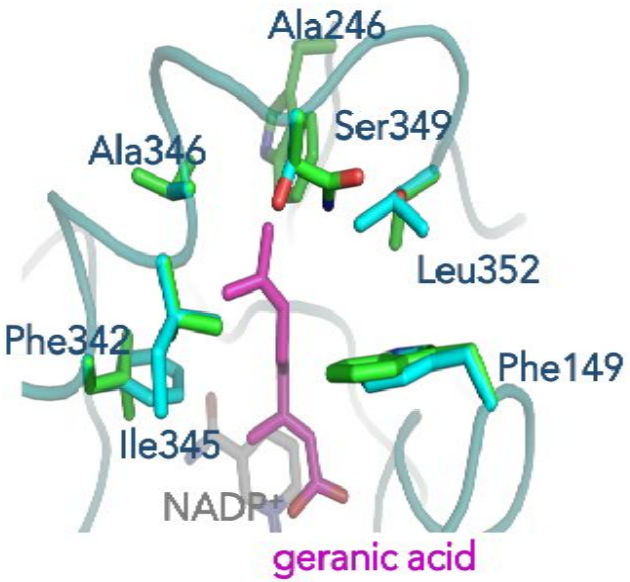
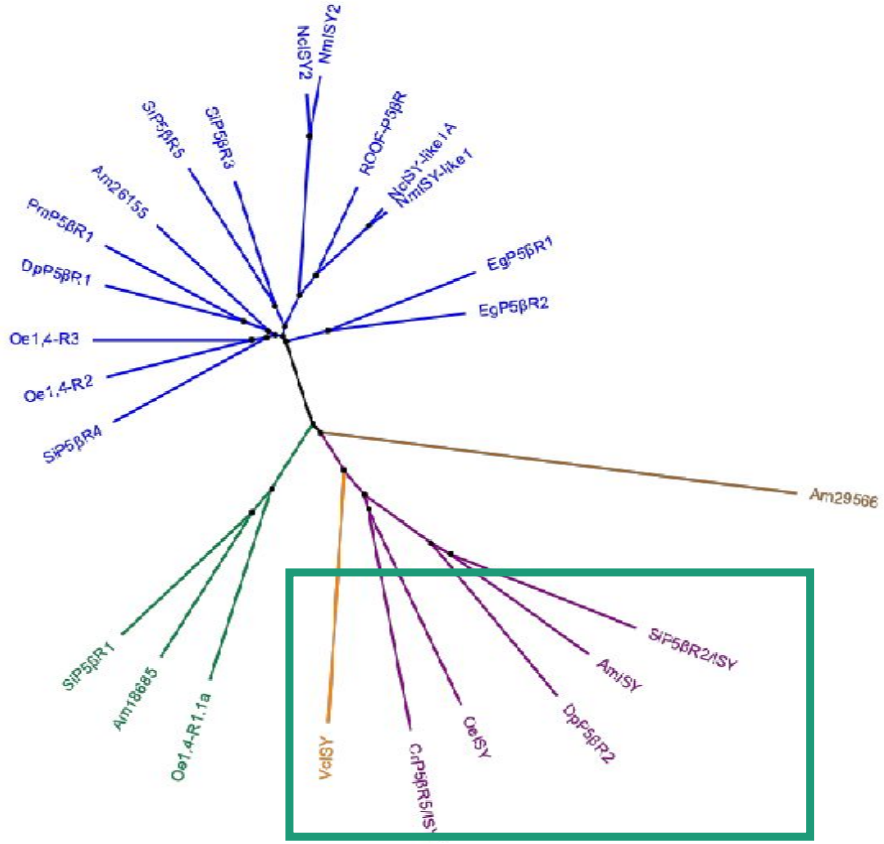
Key residues present



	% ID	149	246	342	345	346	349	352
CrISY	100	F	A	F	I	A	S	L
VcISY	66.4	F	A	F	I	V	S	L

Cr: *C. roseus*
Vc: V. corybosum

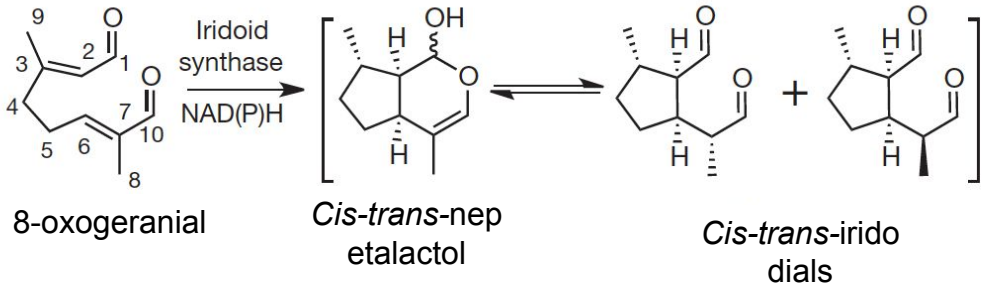
Grouping with validates ISYs



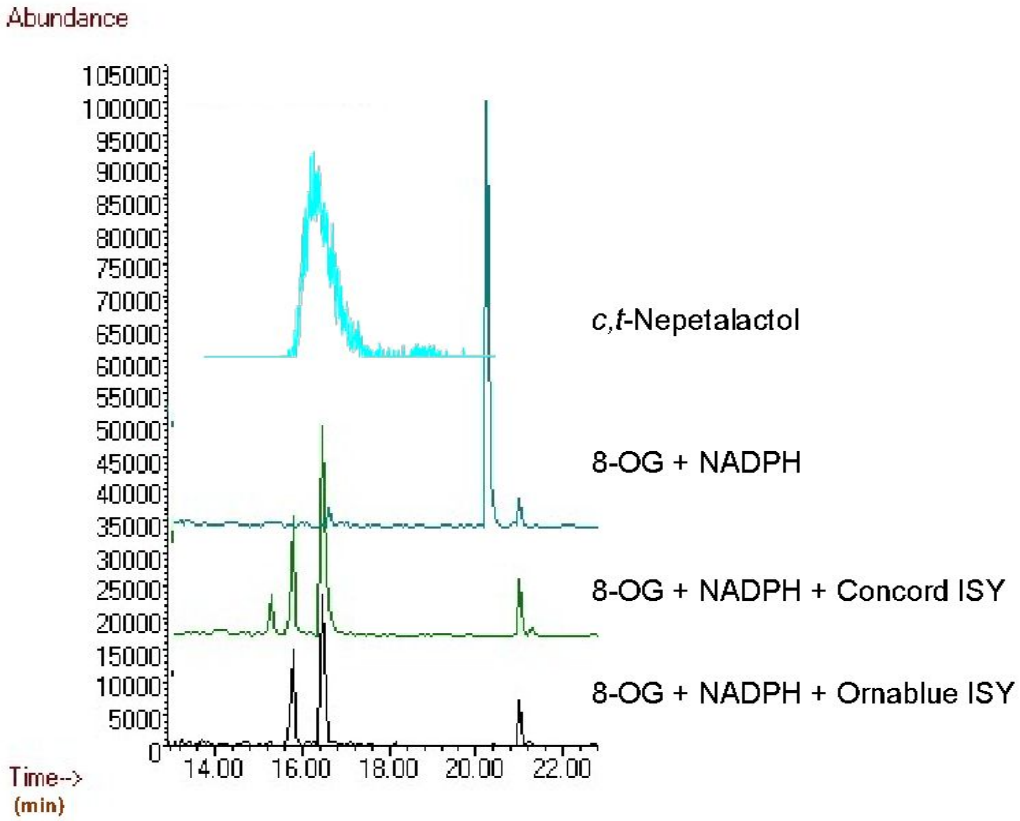
Lawas et. al. (*In revision Plant Direct*)

Vaccinium iridoid synthase

Ornablue and Concord ISY catalyzed the step converting 8-oxogeranial to nepetalactol

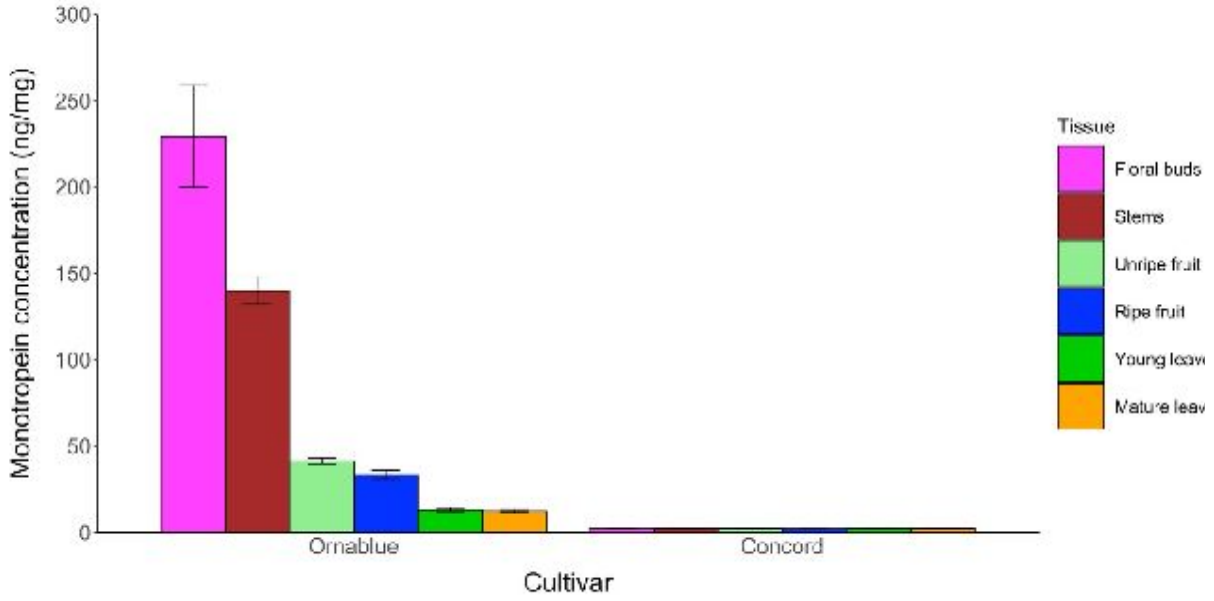


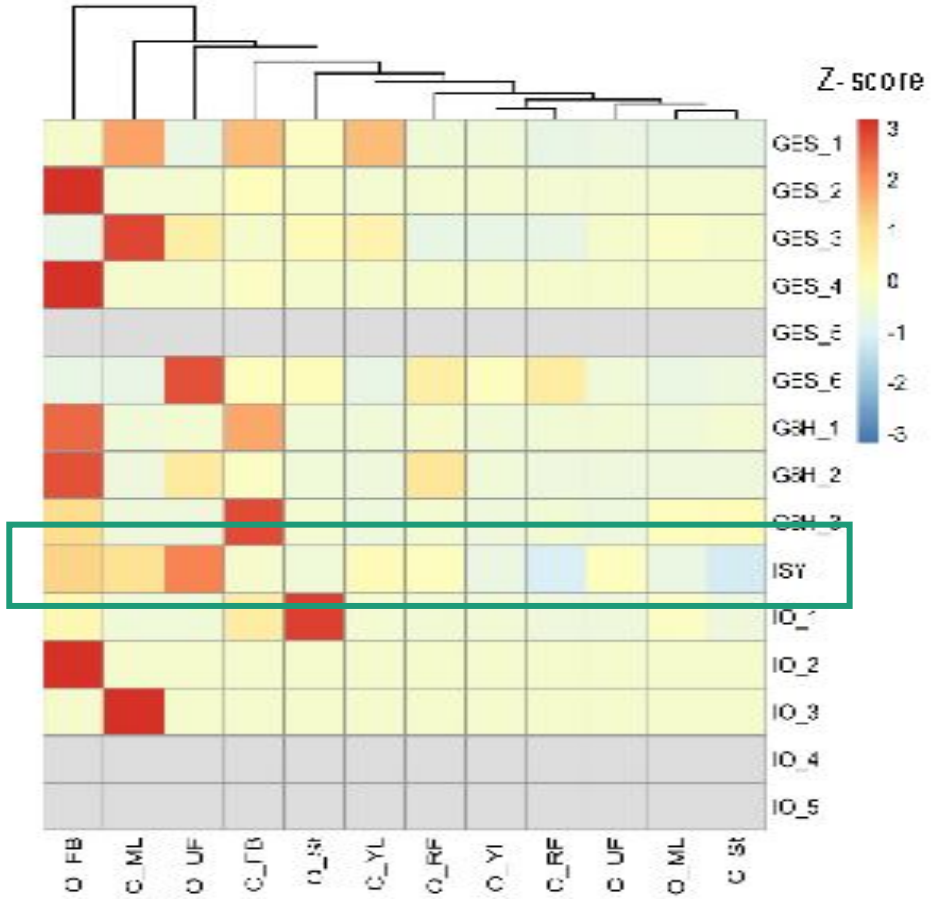
End-point assay for enzyme function



Lawas et. al. (*In revision Plant Direct*)

Ortholog expression analysis





Lawas et. al. (*In review Plant Direct*)

Exploring natural product biosynthesis in blueberry

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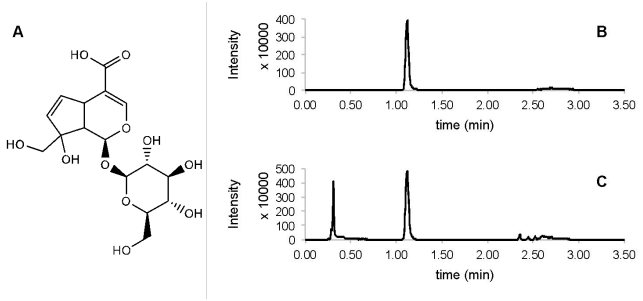
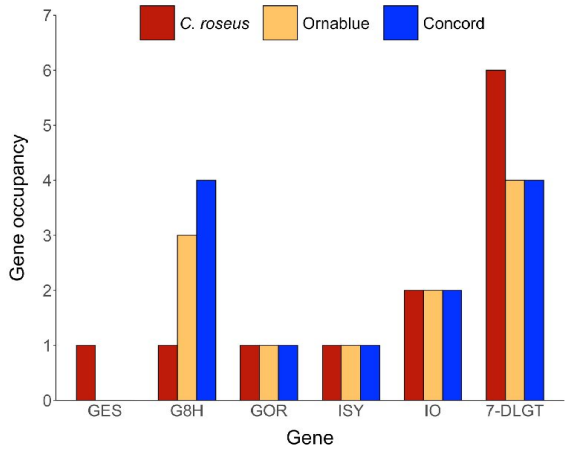
Natural diversity



Metabolite analysis

Orthology
Transcriptomics
Coexpression



Collaborator: Sarah O'Connor
Funding: USDA AFRI

Exploring natural product biosynthesis in blueberry

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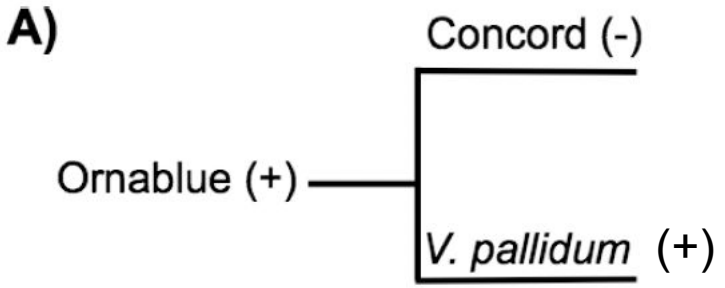
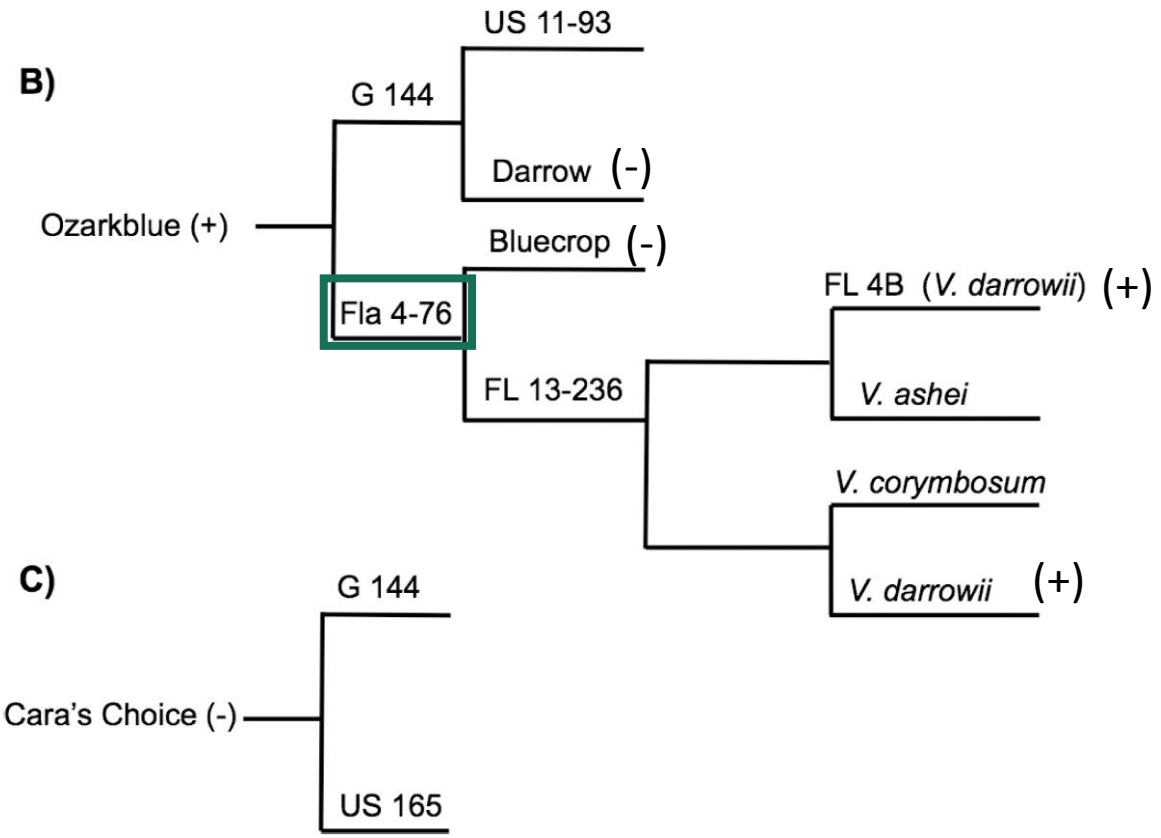
Cultivar or Genotype	Monotropein status
Krewer (RE)	**Positive**
Tifblue (RE)	**Positive**
Titan (RE)	**Positive**
Star (SH)	**Positive**
Suziblue (SH)	*Negative*
Biloxi (SH)	*Negative*
Georgia Dawn (SH)	*Negative*
V. pallidum	**Positive**
V. tenellum	**Positive**
V. darrowi	**Positive**

Exploring natural product biosynthesis in blueberry





Leisner et al., (2017) PLoSONE

Climate change impacts in perennial cropping systems

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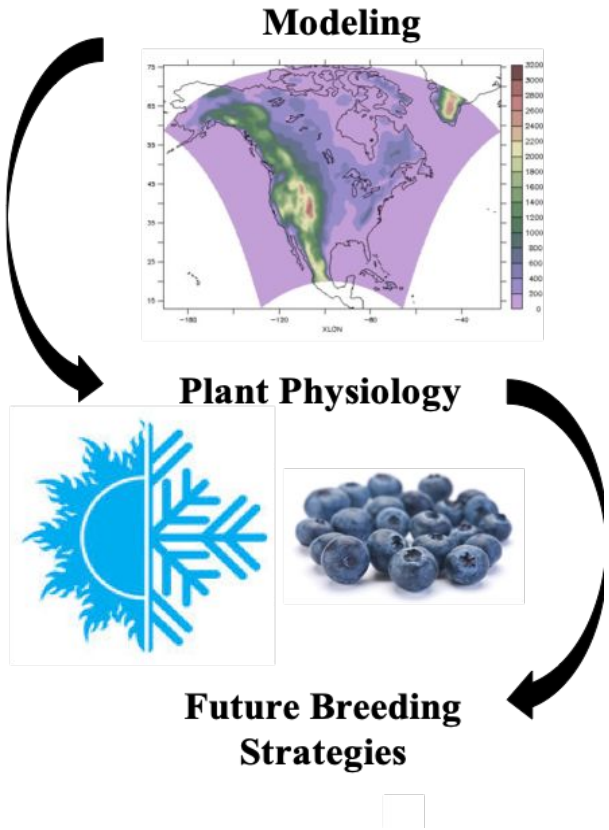
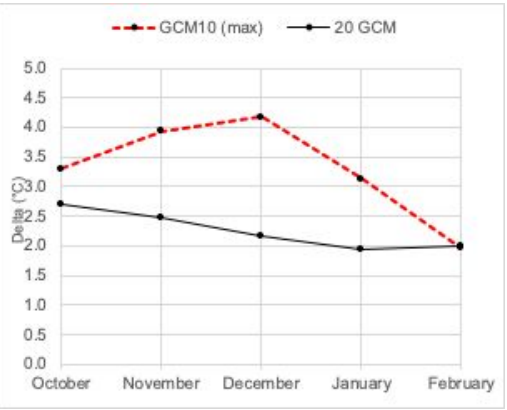
Global climate modeling



Controlled growth chamber experiments



Climate change impacts in perennial cropping systems

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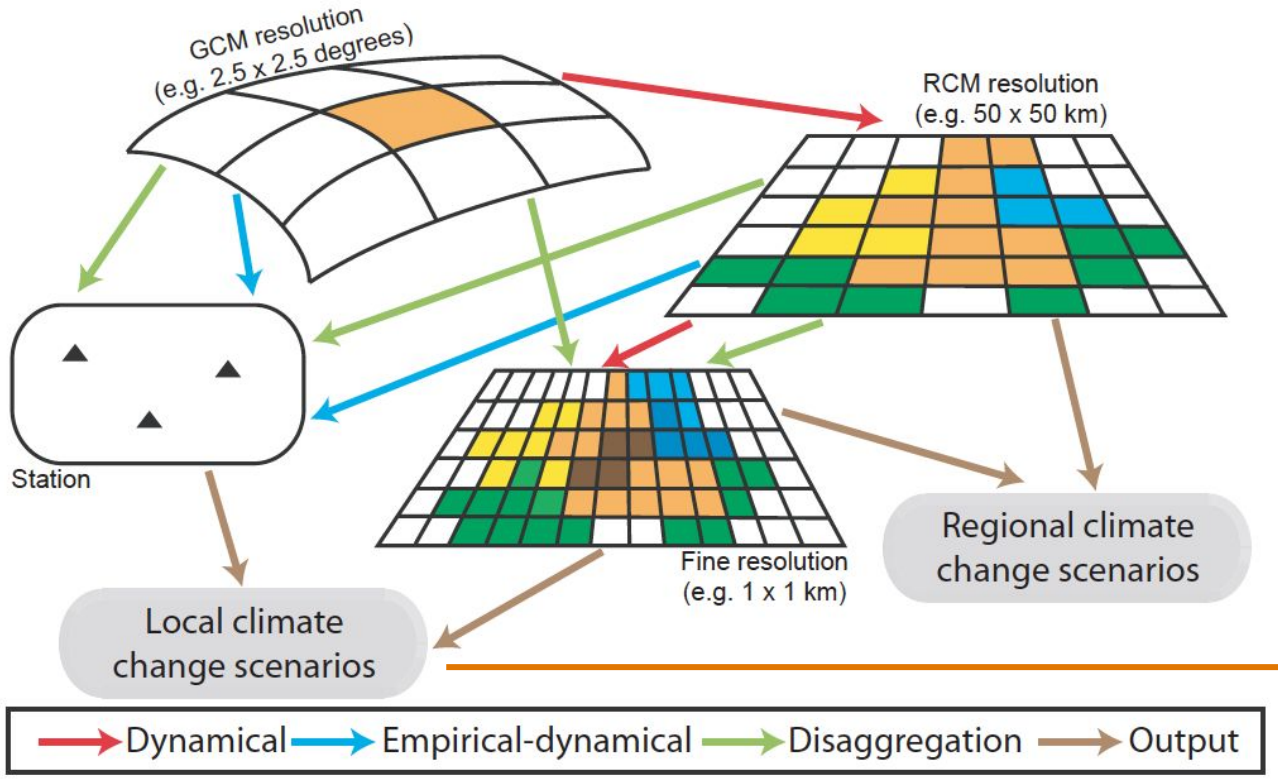
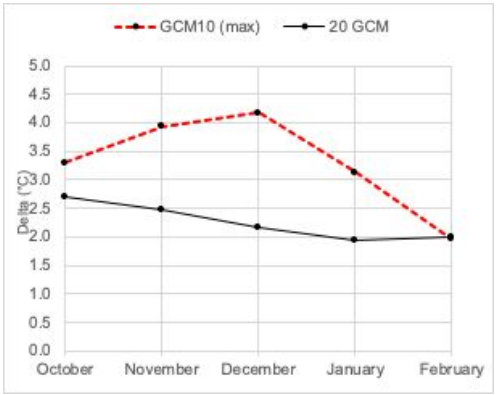
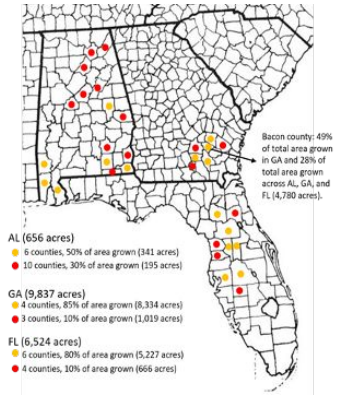
Global climate modeling







Winkler et al., 2012

Climate change impacts in perennial cropping systems

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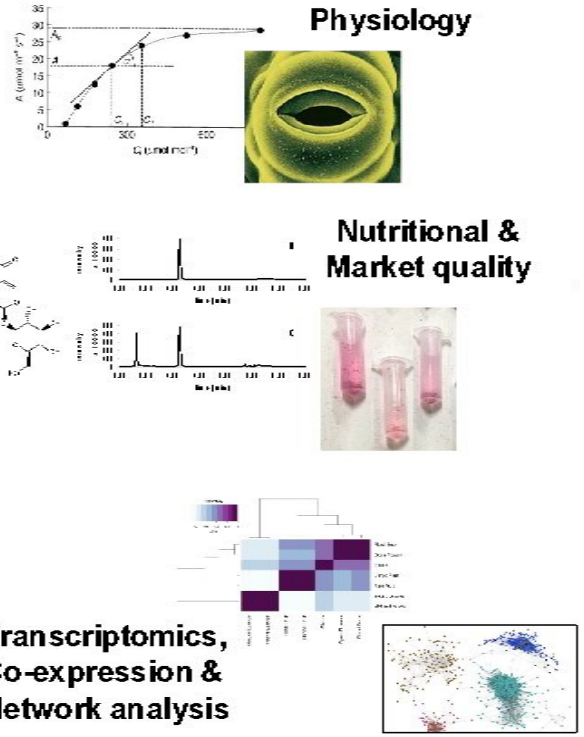
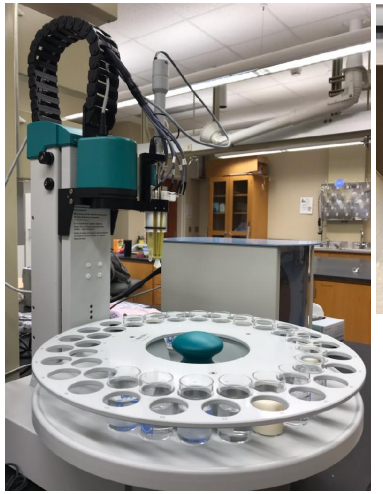
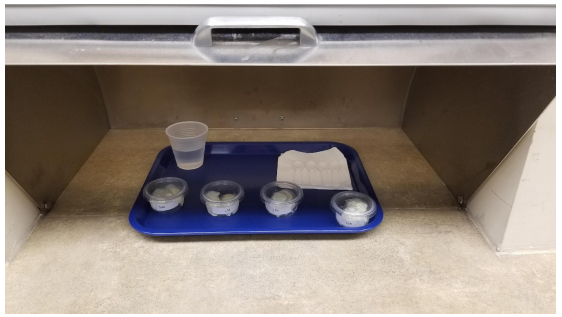
Physiology and nutritional quality



Market quality





Courtesy: Sungeun Cho

Collaborators: Jay Spiers, Sushan Ru, Melba Salazar-Gutierrez
Funding: AAES

Climate change impacts in perennial cropping systems

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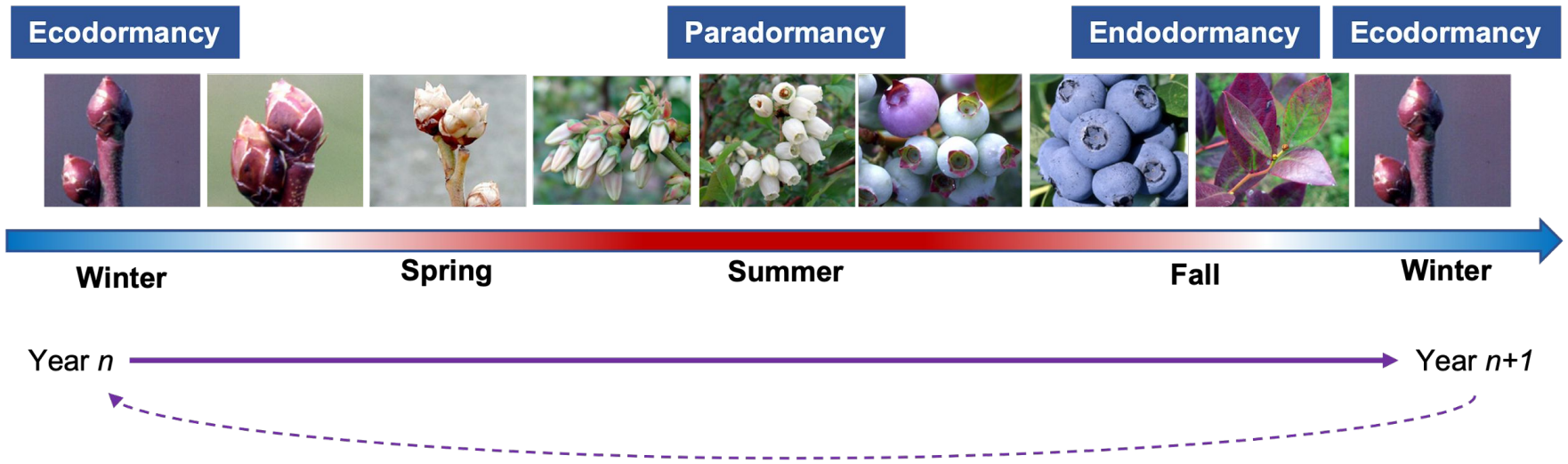
Understand the impact of temperature on dormancy in perennial species



Climate change impacts on perennial cropping systems

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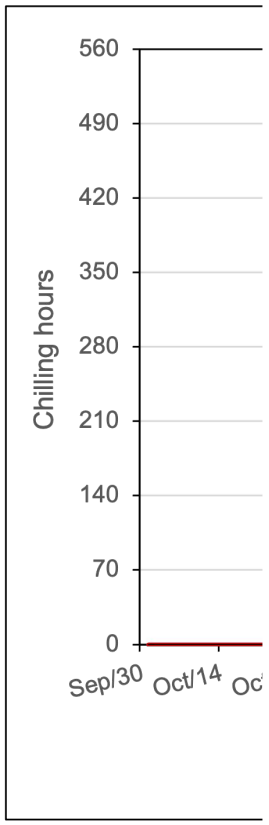
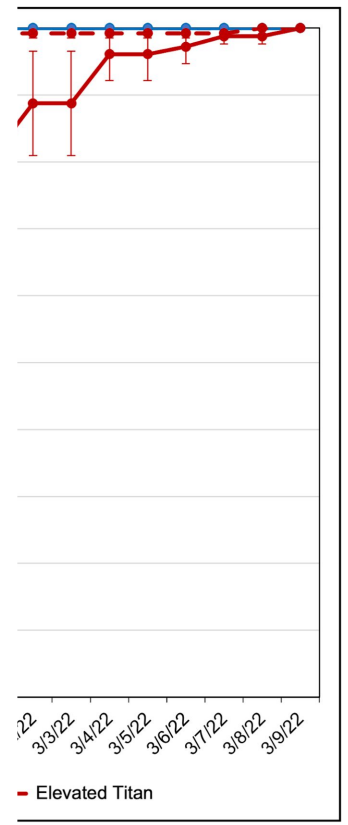


Critical day length/ temperature

Chilling requirement fulfilled

Auxin, cytokinin, GA, ABA, sugars	Phytochromes, ABA, water status	ABA, cell-cell communication
Paradormancy	Endodormancy	Ecodormancy
FT, CO, GI	ABI1, ETR1, FCA, FLC-like, FIE, SVP, DAM, CALS1	ABA/GA genes, cell-cell communication, epigenetic marks?



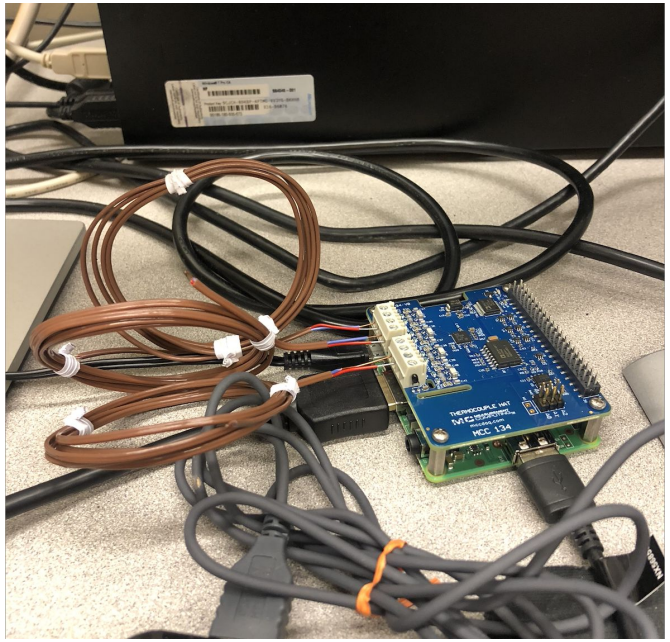
Breeding for climate resiliency in perennial crops

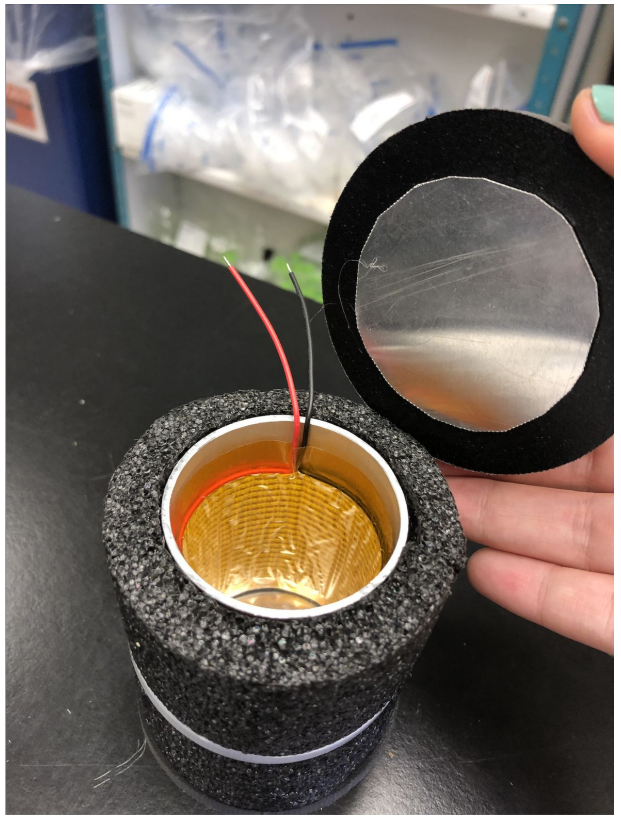
Lovely Lawas

Climate change impacts in perennial cropping systems

LEISNER LAB

Polar pod system to analyze freeze damage in blueberry buds





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Acknowledgments

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