UF IFAS
UNIVERSITY of FLORIDA

How breeding can help lettuce growers manage challenges!

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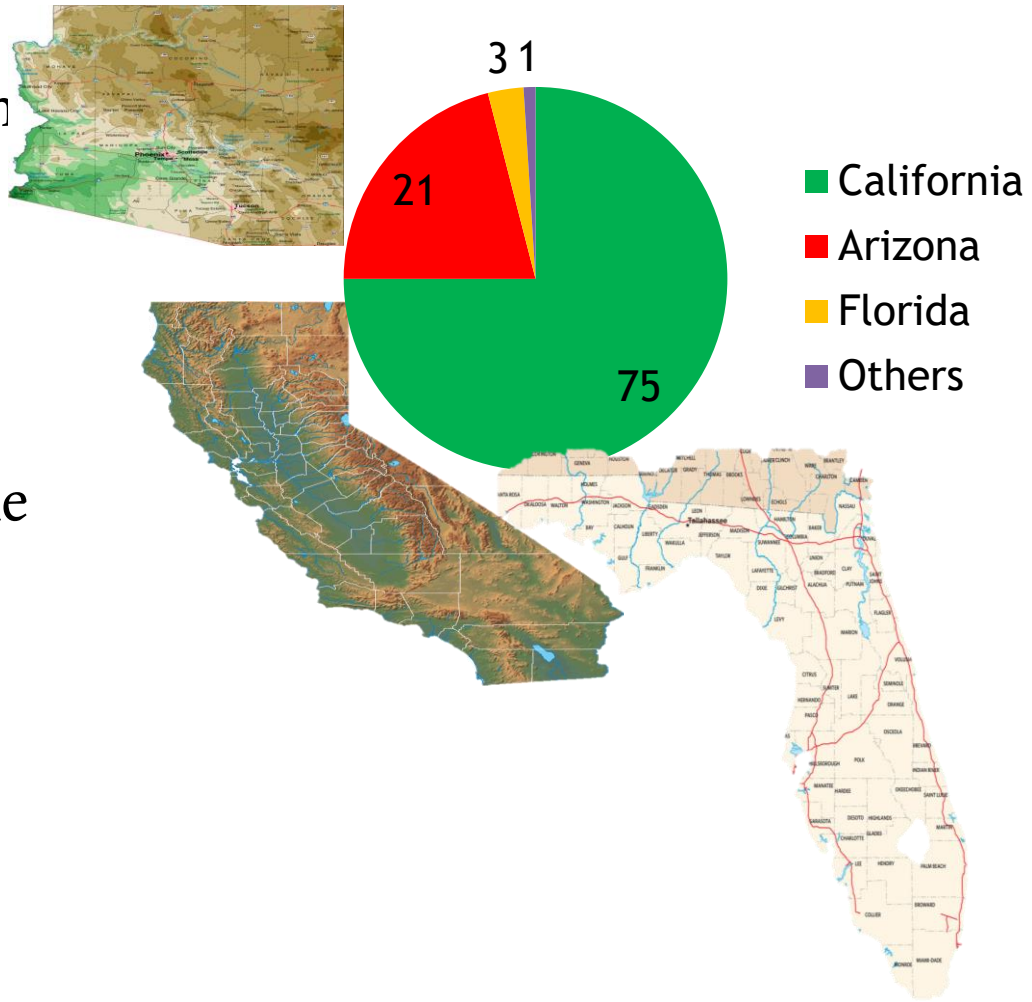
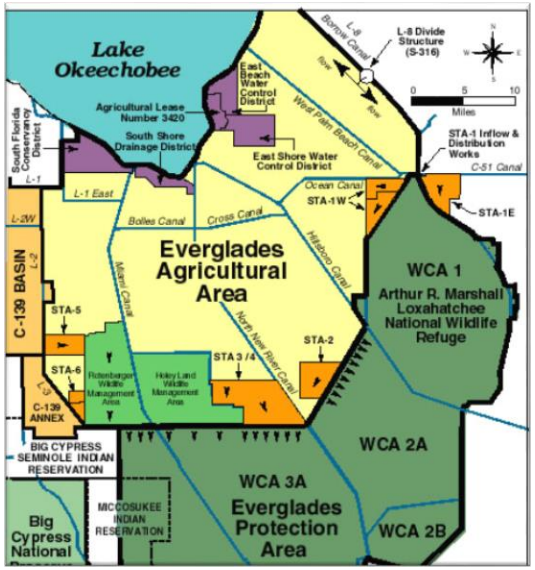
Importance of Lettuce as a Crop

- After China, the USA is the second biggest producer
- In the US alone is a $ 3 billion dollar business
- High profitable crop – Specialty Crop
- California and Arizona are the biggest lettuce producer
- Florida situates third



Lettuce in Florida

- 15,000 acres are planted at the Everglades Agricultural Area (EAA)
- “Muck soil” rich in organic matter (>80%)
- Lettuce is a winter vegetable at the EAA (October to April)
- 60 to 70 million dollar business

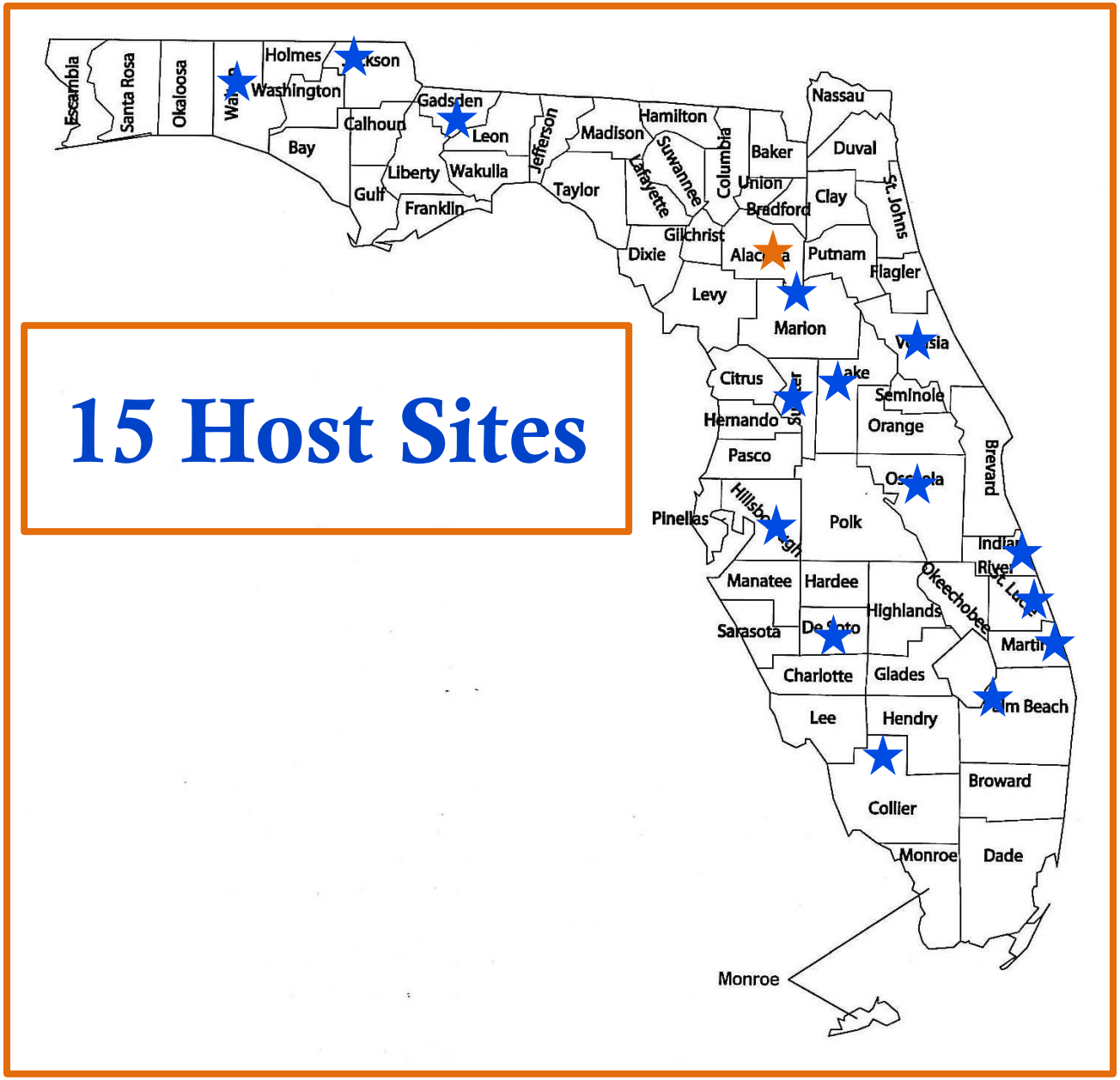


Field Growers

Lettuce in Florida

- How many growers and what's the area planted?
- Hydroponics
- Aquaponics
- Vertical structures
- Greenhouse
- High tunnels (Organic growers)

"Smaller Growers"


15 Host Sites
Escambia
Santa Rosa
Okaloosa
Holmes
Washington
Calhoun
Gadsden
Leon
Jefferson
Madison
Hamilton
Suwannee
Columbia
Nassau
Duval
Baker
Union
Bradford
Clay
St. Johns
Bay
Liberty
Wakulla
Gulf
Franklin
Taylor
Lafayette
Gilchrist
Dixie
Putnam
Flagler
Levy
Marion
Citrus
Hernando
Pasco
Seminole
Orange
Brevard
Pinellas
Polk
Manatee
Hardee
Highlands
Okeechobee
Sarasota
Charlotte
Glades
Lee
Hendry
Broward
Collier
Monroe
Dade
Monroe

Lettuce Breeding – University of Florida

- Everglades Research and Education Center – EREC
- Mission: Improve Lettuce Cultivars for Florida Production
- History: Victor Guzman developed historical lettuce cultivars
  - Short Guzmaine
  - Tall Guzmaine
  - Floriglade
  - Floricos
  - Floribibb

Table 1 Genetic contribution of selected ancestors of lettuce cultivars registered in U.S. 2000 through 2010

Ancestor	Pedigree[b]	Type[c]	Among leaf[a]		Among romaine		Among crisphead	
			Genetic contribution[d]	# Desc[e]	Genetic contribution	# Desc	Genetic contribution	# Desc
Salad Bowl	BL 1893/BL 1885	Leaf	3.5	7	0		0	
Waldmanns Green	Grand Rapids Selection	Leaf	6.1	7	0		0	
Malibu	Unknown	Leaf	6.4	8	0		0	
Parris Island Cos	PI 120965/Dark Green Cos	Romaine	13.5	9	25.9	21	0.6	2
Tall Guzmaine	Short Guzmaine/Paris White	Romaine	0		23.4	24	0.6	1
Vanguard	BL 5550/BL 5504	Crisp	1.3	1	0		23.8	41
Salinas	Calmar/BL 8830	Crisp	0.9	1	4.1	8	12.1	29
Calmar	Great Lakes A-36//Great Lakes 6238 USDA 45325	Crisp	0.6	1	2.3	9	10.9	35

[a] Lettuce type categorized as leaf (39 cultivars), romaine (47), or crisphead (60) for the 146 leaf, romaine, and crisphead cultivars registred by U.S. Plant Variety protection (PVP) or utility patent from 2000 through 2010 that had pedigree derivation available PVP/patent

[b] Pedigree format written per Purdy et al. (1968). Abbreviations include breeding line (BL) and plant introduction (PI)

[c] Lettuce type categorized as leaf, romaine, or crisphead (crisp)

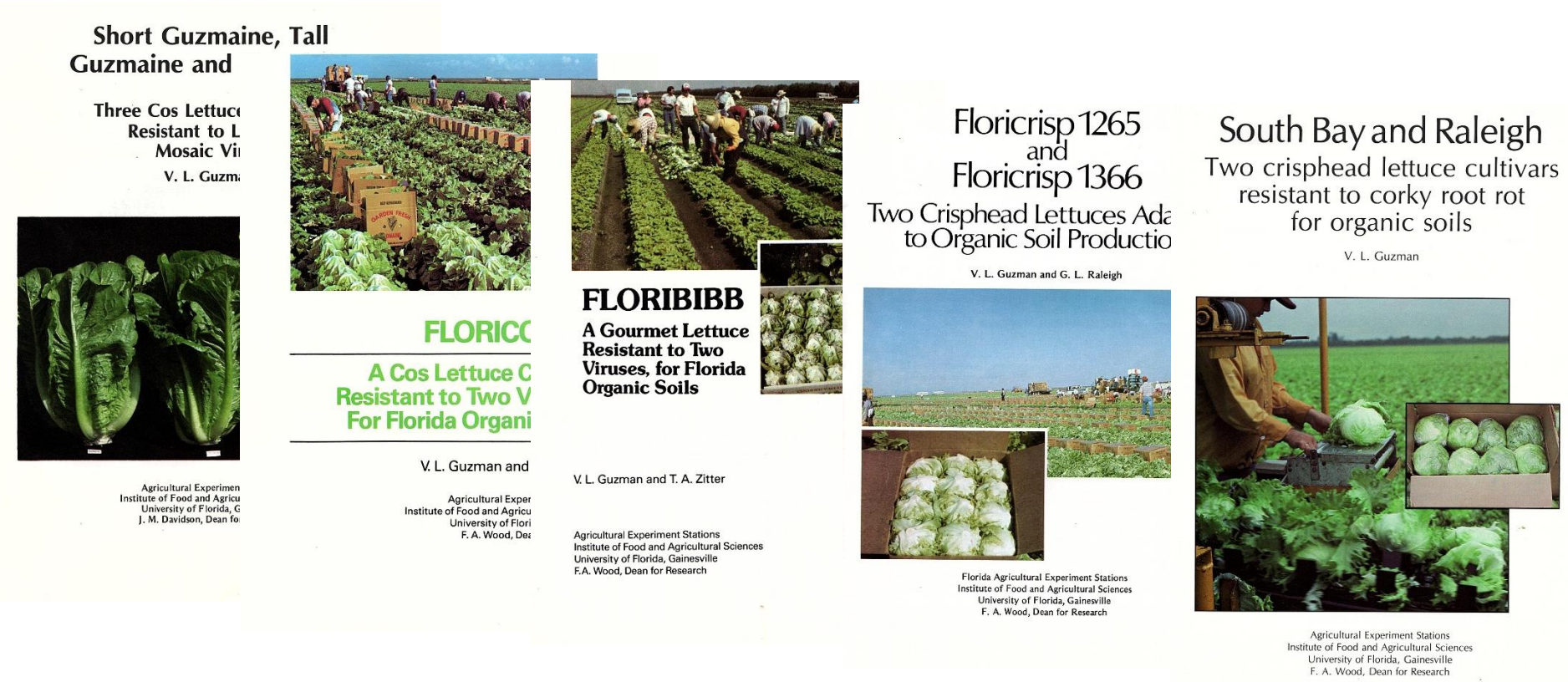
[d] Genetic contribution is based on pedigree analysis and is the theoretical portion of genes contributed by the respective ancestor as determined by coefficient of parentage

[e] Number of lines descending from each respective ancestor

Mikel, 2012

Lettuce Breeding Program at UF

- Improve lettuce cultivars adapted to Florida conditions
- The program aims to develop cultivars of crisphead (iceberg and boston), cos (romaine), leaf, and niche types (Latin)



Lettuce Types

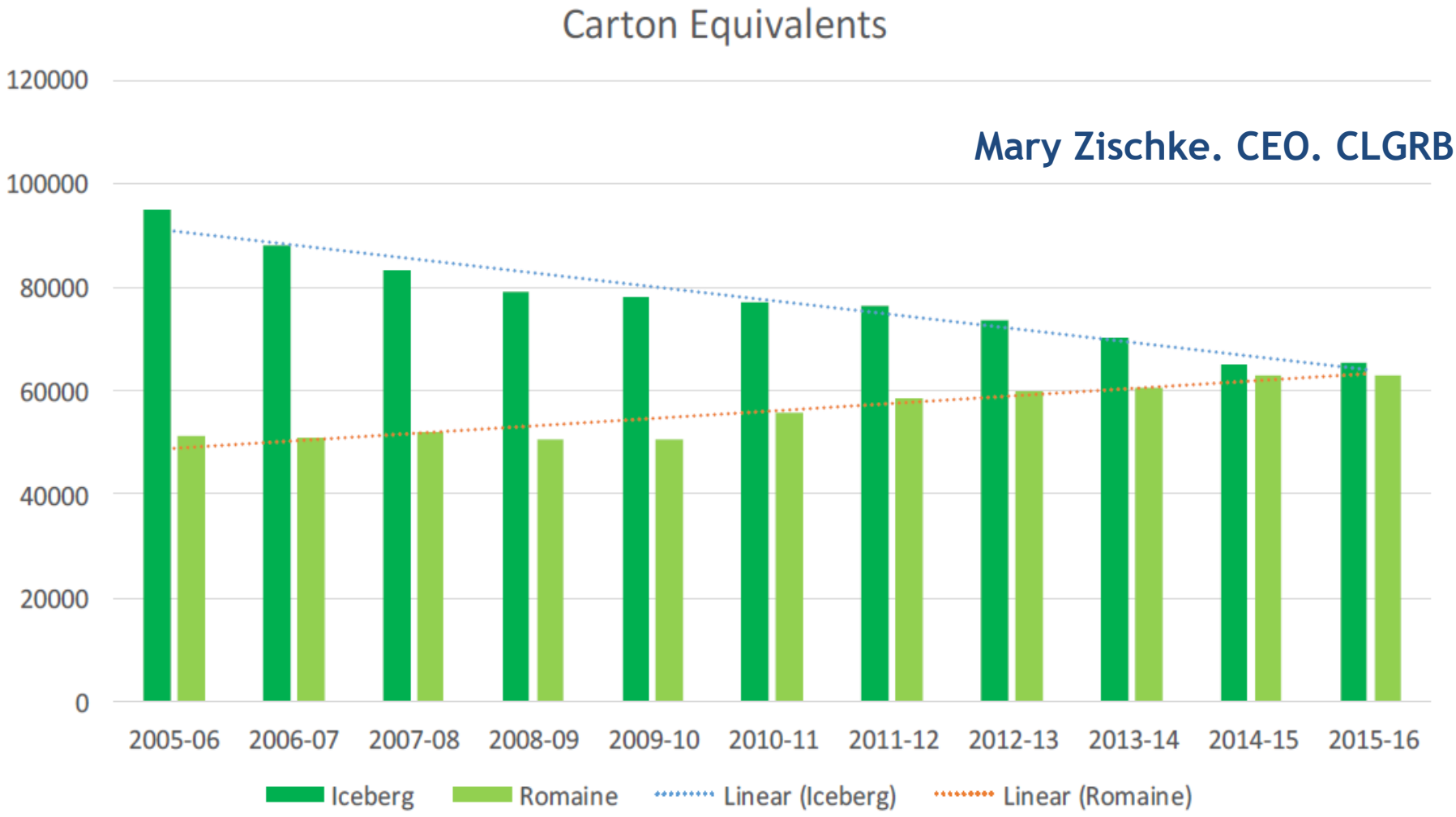
Lactuca sativa L.

- Crisphead
- Cos
- Latin
- Cutting
- Oil
- Stem

http://www.wikiwand.com/en/Celtuce

CALIFORNIA LEAFY GREENS
RESEARCH PROGRAM

Volume Trends
Iceberg and Romaine



Mary Zischke. CEO. CLGRB

Lettuce Type

- New types
- New colors
- New shapes

Lettuce Market

- Fresh
  - Whole head
  - Processed lettuce
  - Baby Leaf
  - Other uses?

http://www.wikiwand.com/en/Celtuce

Baby Leaf Production

- Shapes and colors
- Resistant to lettuce BLS
- Batavia Reine des Glaces

Hayes et al, 2014

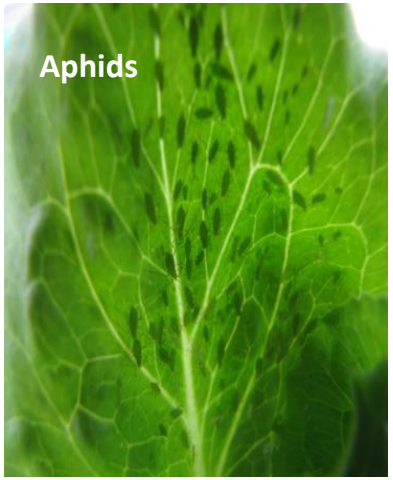
Biotic Stresses
Pests and diseases in Lettuce

Insect pests

Lettuce aphid – *Nasonovia ribis nigri*

The green peach aphid - *Myzus persicae*

Leaf miners – *Liryomiza trifolii*



Diseases

Oomycete

Downy mildew – *Bremia lactucae*

10 Races in the USA and 15 in Europe

Biotic Stresses
Pests and diseases in Lettuce

Diseases

Fungal

Sclerotinia drop – *Sclerotinia sclerotiorum S. minor*

Verticillium wilt – *Verticillium dahliae*

Fusarium wilt – *Fusarium oxysporum fsp. lactucae*

Bacterial

Corky root rot – *Rhizomonas suberifasciens*

Bacterial Leaf Spot – *Xanthomonas campestris pv. vitians*

Virus

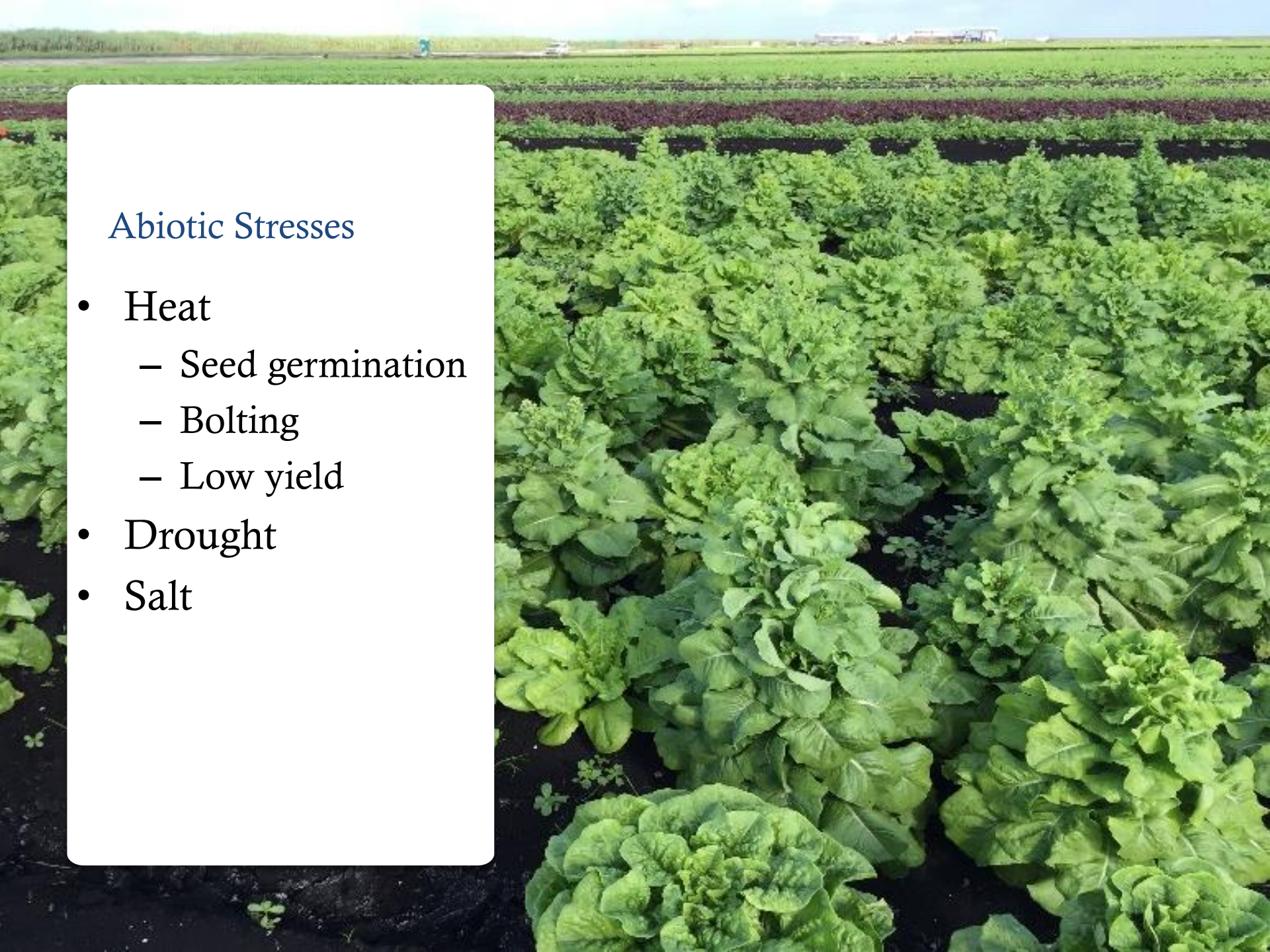
Dieback – *Tomato bushy stunt virus* and *lettuce necrotic stunt virus*

Lettuce mosaic – *Lettuce Mosaic Virus*

Big vein - *Mirafiori lettuce virus*

Abiotic Stresses

- Heat
  - Seed germination
  - Bolting
  - Low yield
- Drought
- Salt

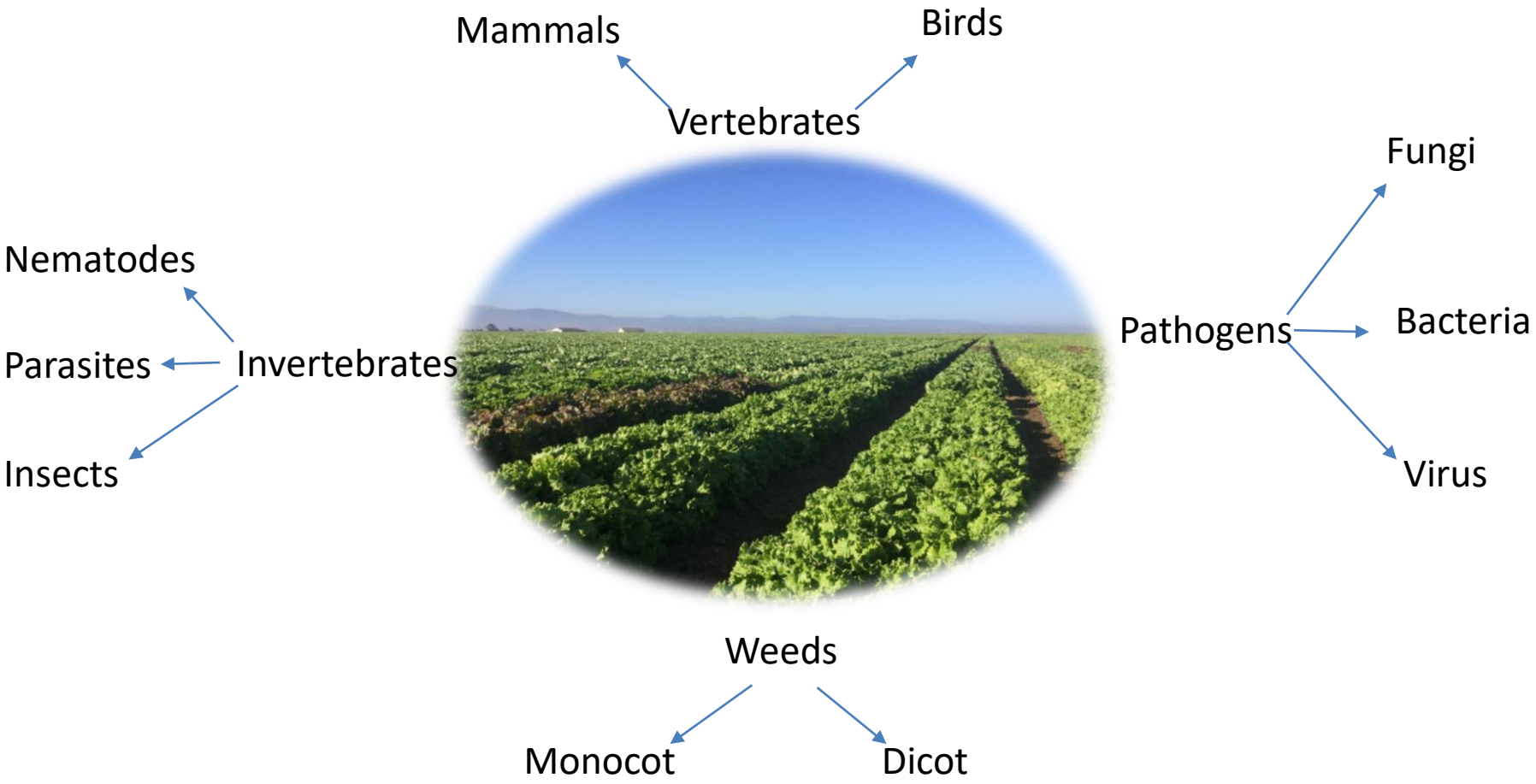


Other problems in Lettuce

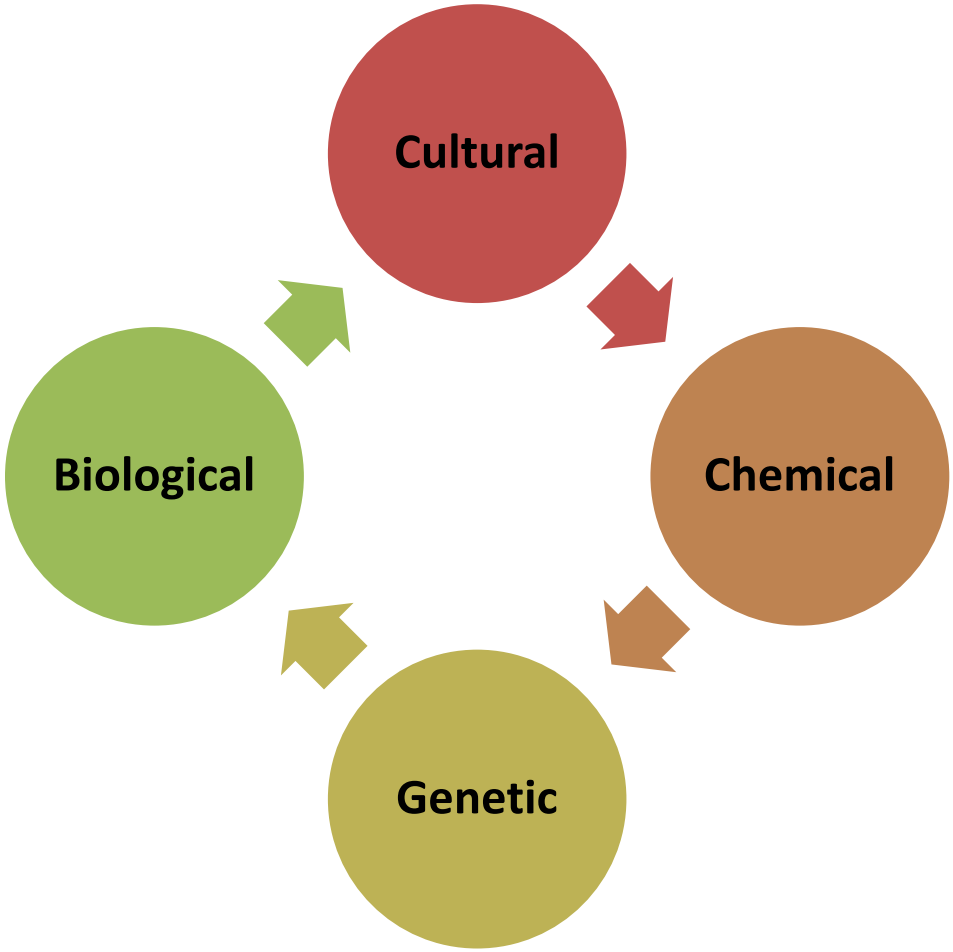
- Bolting
- Tipburn (Calcium deficiency)
- Cercospora Leaf Spot
- Post harvest quality
  - Salad Shelf-Life
  - Arrival Quality

What is a pest?

Pest: a plant or animal detrimental to humans or human's concerns



Integrated Pest Management



Lettuce Breeding Program at UF

The case of Bacterial Leaf Spot (BLS)

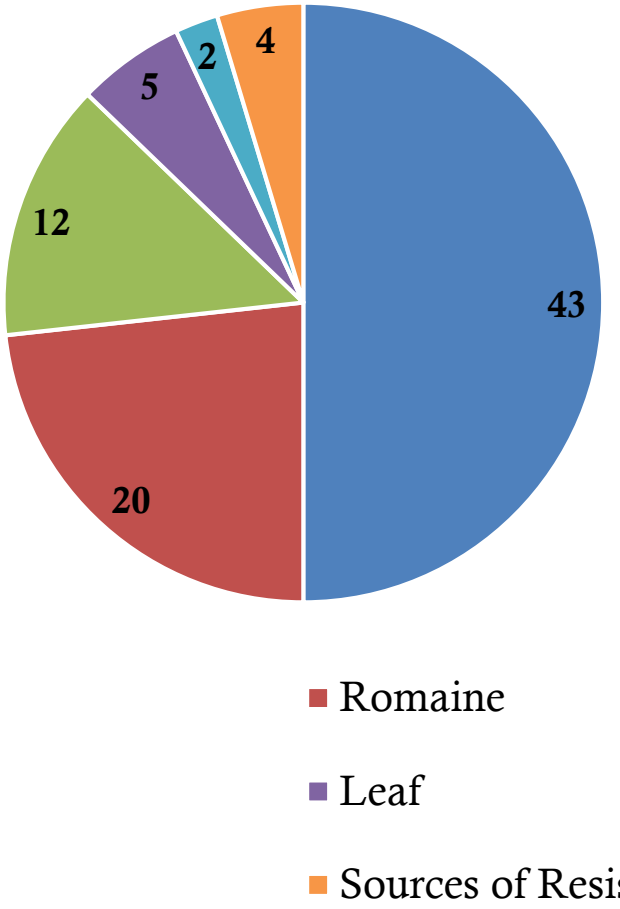
- *Xanthomonas campestris* pv. *vitians* – several races
- Present in lettuce production areas (subtropical - Florida)
- Sudden outbreaks have caused million dollars losses (Florida)
- No chemical pesticide is available, breeding is the most reliable option

Transfer resistance to adapted iceberg and romaine cultivars

The case of Bacterial Leaf Spot (BLS)

PI 358001-1 (Resistant)

Crosses to PI 358001-1



Lettuce Breeding Program at UF

The case of Bacterial Leaf Spot (BLS)

Backcross Selection Scheme

BC_2F_2

BLS resistant lettuce

- Search for additional sources of resistance
- PI 358001-1
  - Fast Bolter
  - Sensitive to Tipburn
  - Leaf characteristics are predominant
  - More than one race of BLS is known (Florida – race 1 only)
- 65 Plant Introductions (PI) and lettuce cultivars resistant to CA strains of BLS in evaluation process

Lettuce Breeding Program at UF

- Fusarium wilt – "New disease" identified in Florida
- Lettuce downy mildew
- Weed control

- *Fusarium oxysporum* f.sp. *Lactucae*
- First in California and Arizona
- New disease in Florida?
- Three races, only one in the USA
- Limited chemical control
- The disease was controlled using methyl bromide
- Breeding is the most reliable option
- Other alternatives are crop rotation, equipment sanitation, flooding

Lettuce Breeding Program at UF

- Fusarium wilt – "New disease" identified in Florida
- Lettuce downy mildew
- Weed control

- *Bremia lactucae* is an universal pathogen (oomycete)
- 15 races in the EU and 10 in the USA
- No information on races of the pathogen in FL
- Growers depend heavily in chemicals
- Although resistance and chemicals are available, the pathogen evolves quickly
- Collecting isolates throughout FL

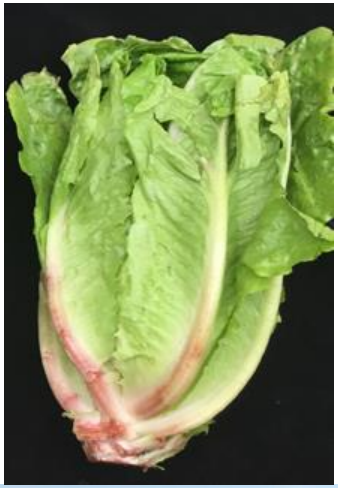
Lettuce Breeding Program at UF

- Fusarium wilt – "New disease" identified in Florida
- Lettuce downy mildew
- Weed control

- Weeds are a big problem for field growers
- Losses are estimated to be 40%
- In field, lettuce is a rotational crop
- Not many chemicals are approved for the rotation
- What would be a solution using breeding?
- Lettuce tolerant to wide spectrum herbicides are needed

Lettuce Breeding Program at UF

- Postharvest
- Nutrient use efficiency
- Heat tolerance



- Shelf-life is needed for lettuce in any type of market
- Pinking and Browning are big issues for growers
- Poor shelf-life in modified atmosphere

- Fertilizers are costly
- Environmental concerns
- In the future, lettuce production will happen in smaller operations

- Heat causes bolting, low yield, losses
- Heat tolerance is needed for field production
- Heat tolerance is needed for greenhouse production

Future of Lettuce Breeding

- What other lettuce types will be in the market?
  - Baby Leaf?
  - Hydroponic Lettuce?
  - Other protected structures?
  - Novel head architecture and head traits?

Lettuce as Source of Vitamins and other Minerals

Table 2. Nutritional content of Cos, Butterhead, Cutting (green and red), Crisphead and Stalk lettuce types based on 100 g fresh weight (USDA 2005b)

Nutrient and units	Lettuce type Butterhead	Cos	Crisphead	Cutting[a]	Cutting[b]	Stalk
Protein (g)	1.35	1.23	0.90	1.36	1.33	0.85
Sugars, total (g)	0.94	1.19	1.76	0.78	0.48	–
Lipids:						
Fatty acids, total saturated (mg)	29	39	18	20	–	–
Fatty acids, total monounsaturated (mg)	8	12	6	6	–	–
Fatty acids, total polyunsaturated (mg)	117	167	74	82	–	–
Phytosterols (mg)	–	–	10	38	–	11
Minerals:						
Calcium (mg)	35	33	18	36	33	39
Iron (mg)	1.24	0.97	0.41	0.86	1.20	0.55
Magnesium (mg)	13	14	7	13	12	28
Phosphorous (mg)	33	30	20	29	28	39
Potassium (mg)	238	247	141	194	187	330
Sodium (mg)	5	8	10	28	25	11
Zinc (mg)	0.20	0.23	0.15	0.18	0.20	0.27
Copper (mg)	0.016	0.048	0.025	0.029	0.028	0.040
Manganese (mg)	0.179	0.155	0.125	0.250	0.203	0.688
Selenium (mcg)	0.6	0.4	0.1	0.6	1.5	0.9
Vitamins:						
Ascorbic acid (mg)	3.7	24.0	2.8	18	3.7	19.5
Thiamin (mg)	0.057	0.072	0.041	0.070	0.064	0.055
Riboflavin (mg)	0.062	0.067	0.025	0.080	0.077	0.070
Niacin (mg)	0.357	0.313	0.123	0.375	0.321	0.550
Pantothenic acid (mg)	0.150	0.142	0.091	0.134	0.144	0.183
Vitamin B-6 (mg)	0.082	0.074	0.042	0.090	0.100	0.050
Folate, total (mcg)	73	136	29	38	36	46
Vitamin A (IU)	3312	5807	502	7405	7492	3500
Vitamin E (mg)	0.18	0.13	0.18	0.29	0.15	–
Tocopherol, gamma (mg)	0.27	0.36	0.09	0.37	0.24	–
Vitamin K (phylloquinone) (mg)	102.3	102.5	24.1	173.6	140.3	–
Carotenoids:						
Carotene, beta (mcg)	1987	3484	299	4443	4495	–
Lutein + zeaxanthin (mcg)	1223	2312	277	1730	1724	–

[a] Greenleaf
[b] Redleaf

Still, 2007

Interaction Industry – UF Lettuce

GET TO KNOW YOUR GROWERS BECAUSE YOU NEED TO KNOW THEIR NEEDS

FIELD SELECTIONS AT THEIR FACILITY

PLANT ADVANCED BREEDING LINES AND GET FEEDBACKS

TARGET ALL GROWERS IN THE STATE

Future of Lettuce Breeding

- What other alternatives do we have in lettuce breeding?
  - Molecular Markers for MAS

    Lettuce genome is sequenced – Version 9

    Newer sequencing technologies - GBS

    Several traits in lettuce have been mapped

    Vegetable breeding companies are likely using MAS

    No many markers have been developed in academia

    Corky Cork Root – *Cor* gene

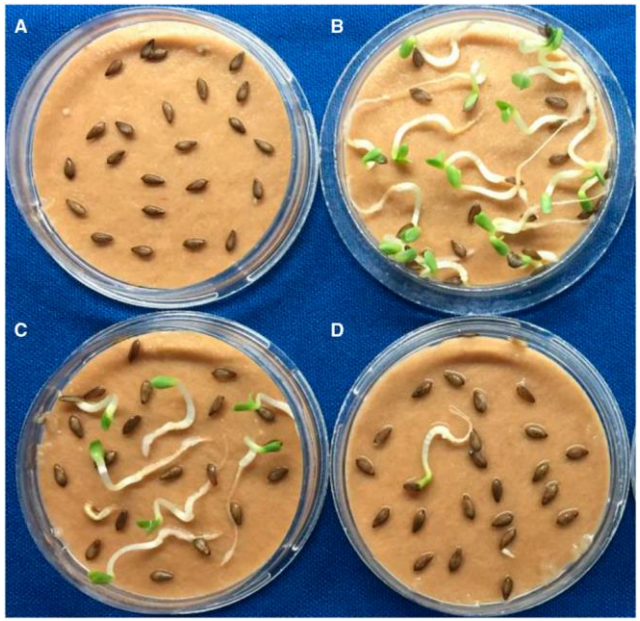
    Lettuce Dieback – *Tvr1* gene

    Verticillium resistance 1 – *Vr1* gene

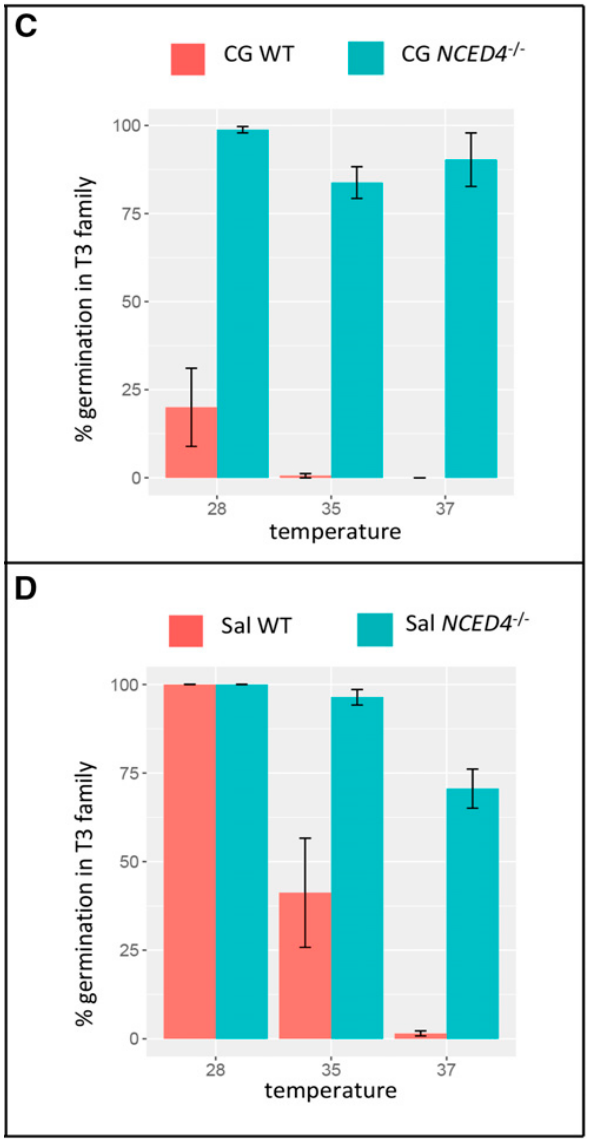
    Bacterial Leaf Spot – *Xar1* or *Xcvr* gene

Future of Lettuce Breeding

- What other alternatives do we have in lettuce breeding?
  - "GMOs" – Genetically engineered?
  - Gene editing?
    - First lettuce mutated lines able to germinate at >35˚C

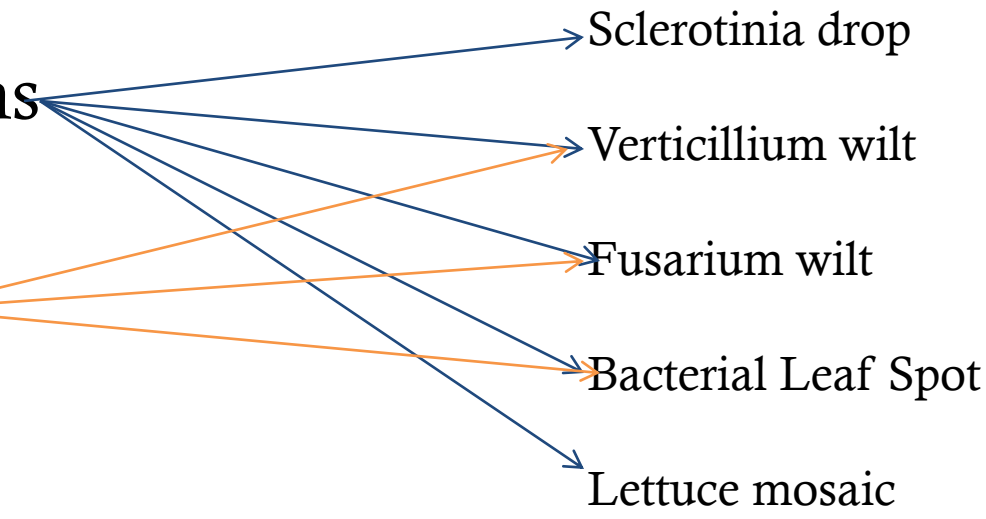


Bertier et al., 2018

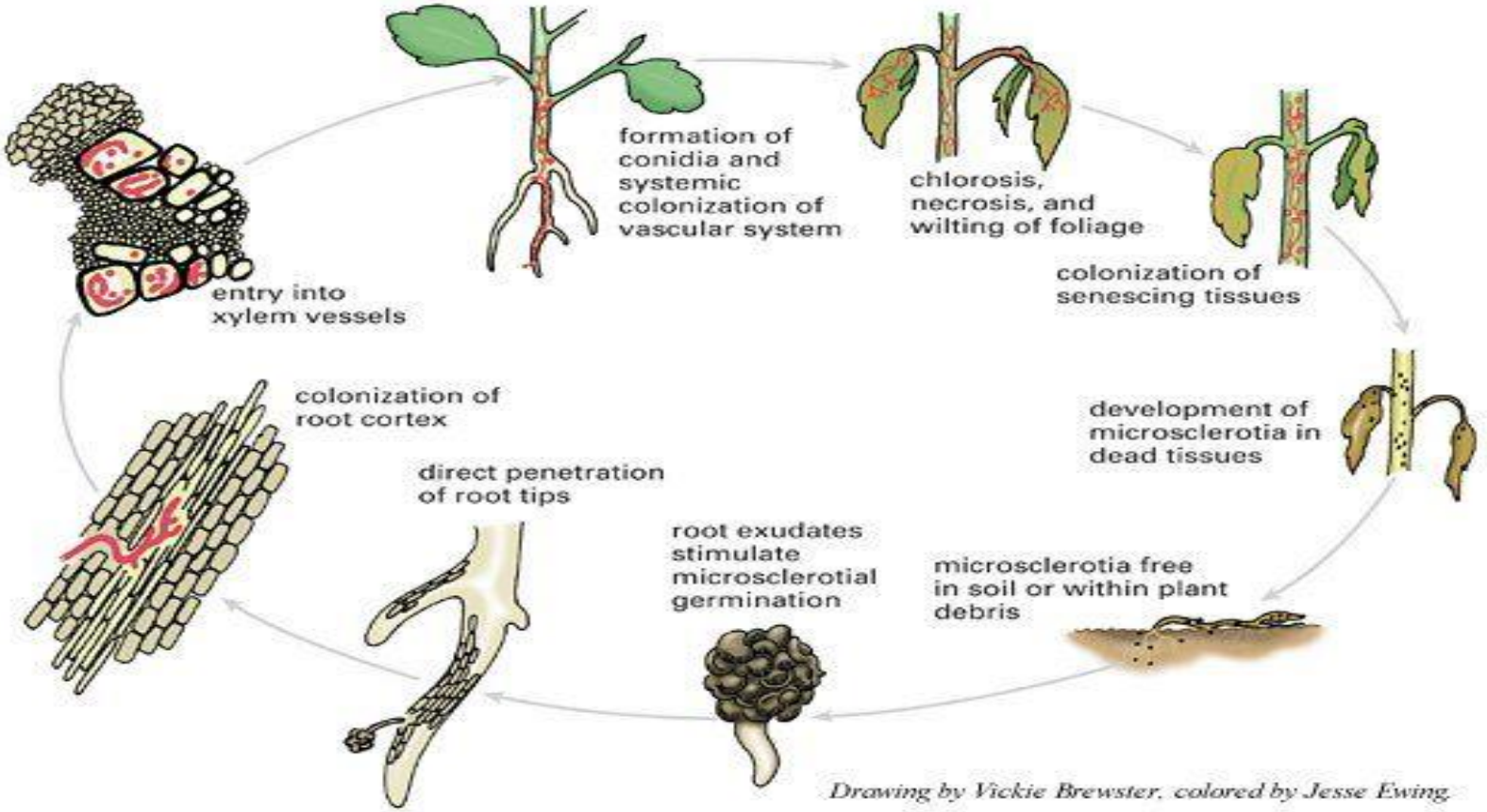


Recommendations

- Seed-borne pathogens
- Limited pesticides



- Use clean seed
- Think of breeding as part of an IPM
  - Use as many resources as you have
- Test your seed for pathogens



http://www.apsnet.org/edcenter/intropp/lessons/fungi/ascomycetes/Pages/VerticilliumWilt.aspx

Recommendations

- Bolting
- Heat Tolerance

➢Use cultivars bred for the specific environment

➢Talk to your specialist

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How breeding can help lettuce growers manage challenges!

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