

A photograph of a sunset over a rural landscape. The sky is filled with dramatic, dark clouds, with a bright orange and yellow glow from the setting sun breaking through. In the foreground, a field of pumpkins is visible, with many orange pumpkins scattered among green leaves and stems. In the middle ground, there is a large green field, possibly a cornfield, with a line of trees in the distance. The overall scene is peaceful and scenic.

Creating Plant Breeding Populations for Organic Systems

**Rachel Hultengren, Lauren Brzozowski, Michael
Mazourek**

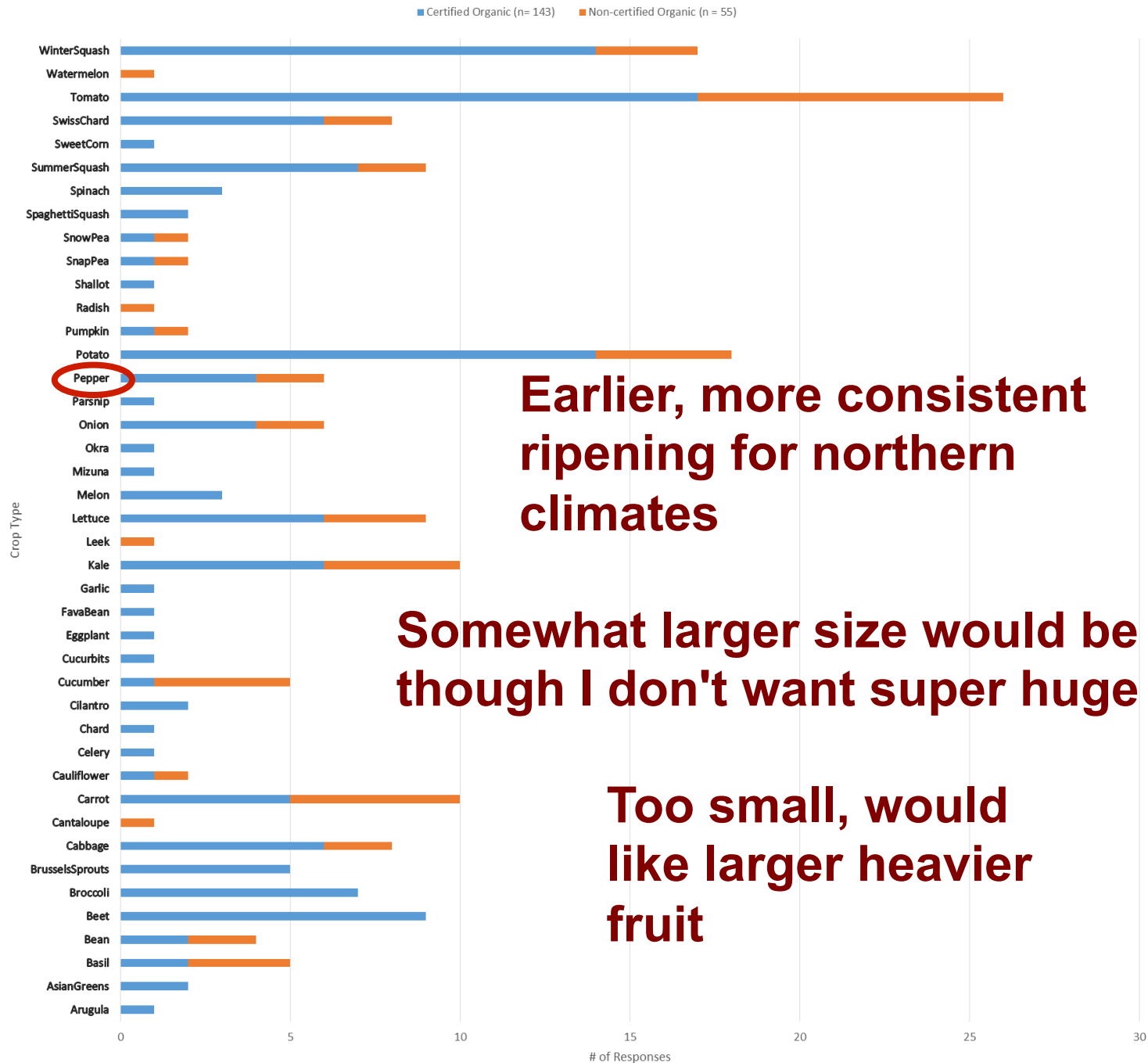
Creating Plant Breeding Populations for Organic Systems:

**Listening to grower needs to
establish breeding priorities**

Organic Vegetable Growers' Needs Assessment Survey

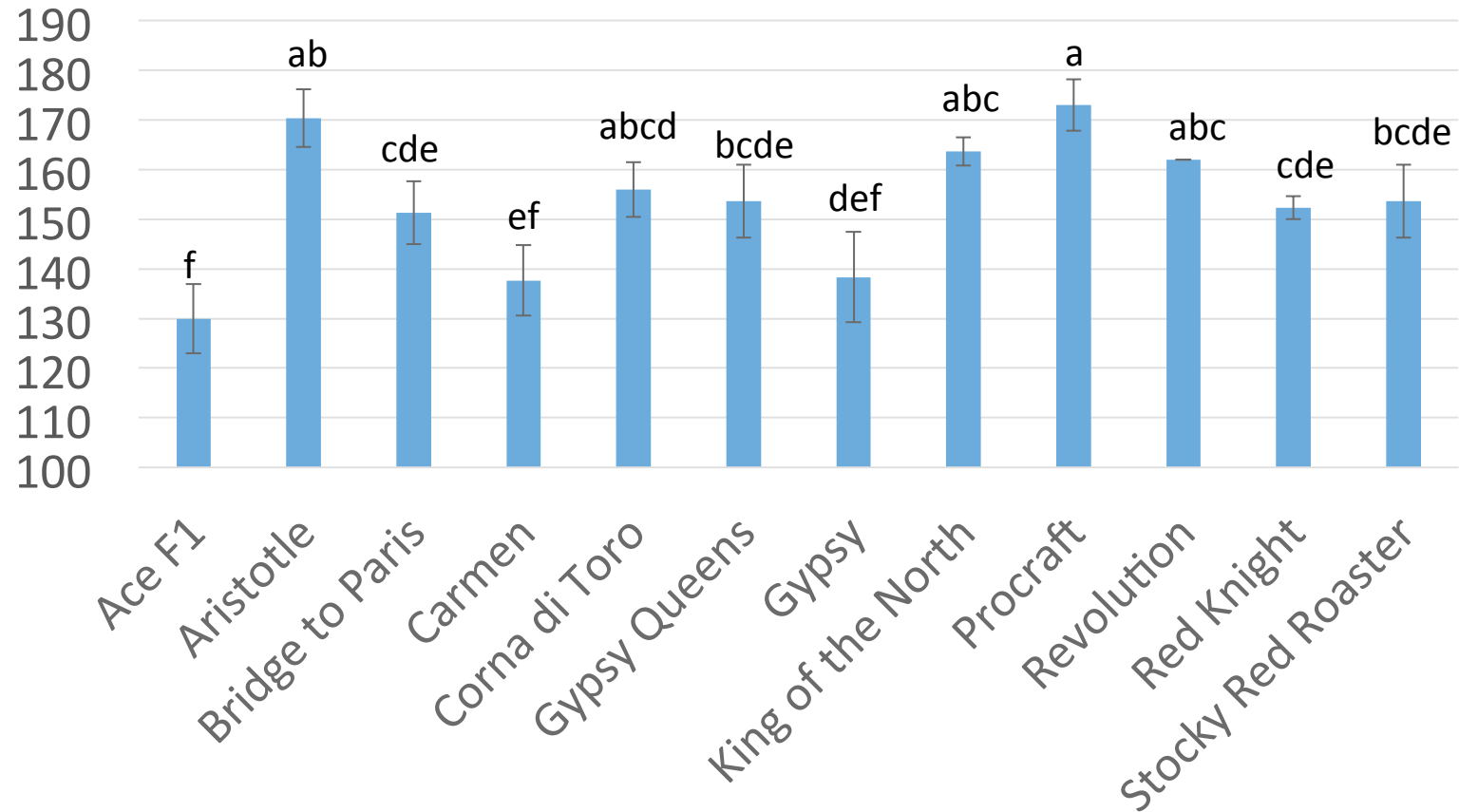
- Online survey sent to certified organic growers across the Northeast
- Shared through partners at farmers organizations
- Received 201 responses

Varieties to Improve

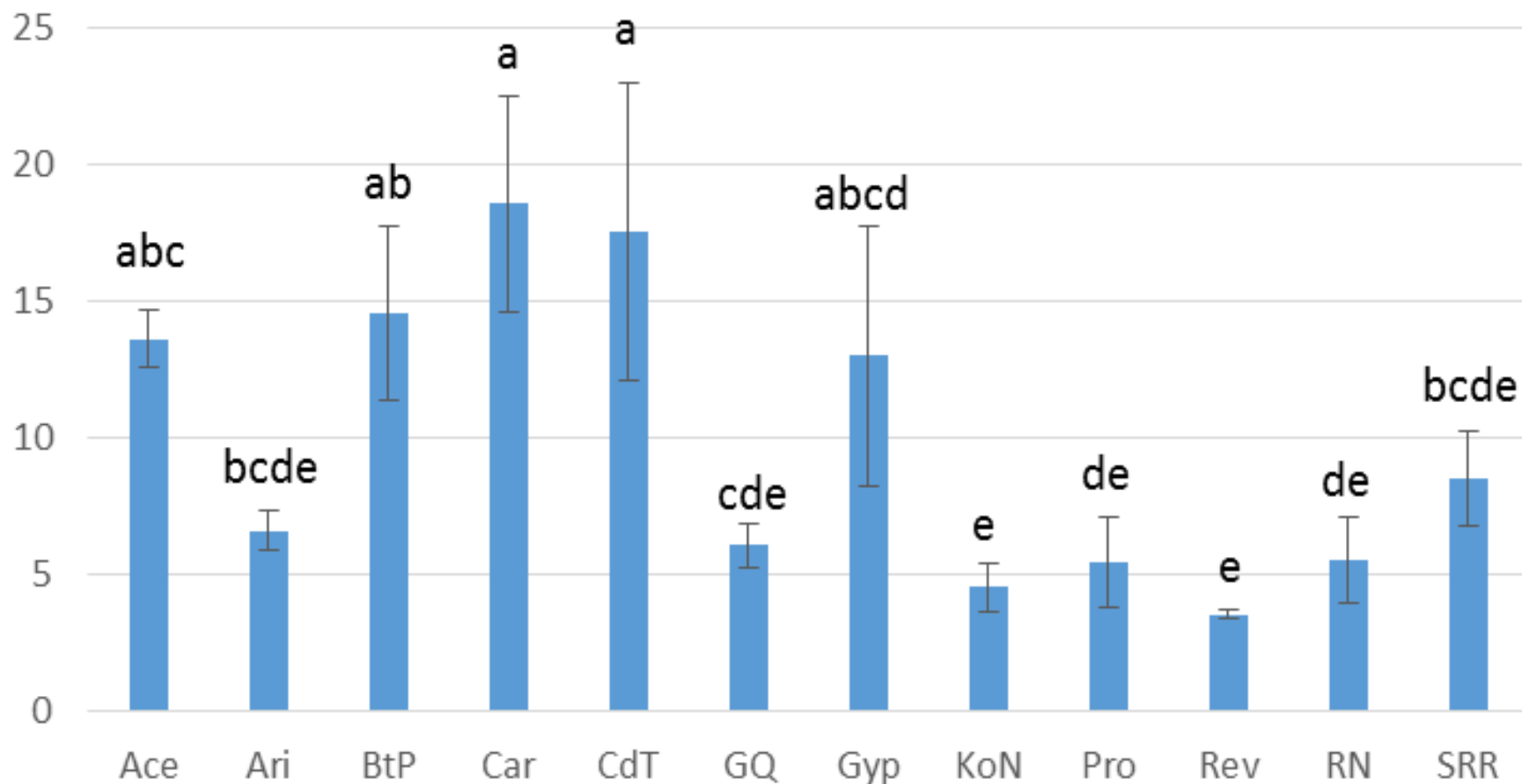




First harvest (days after sowing)

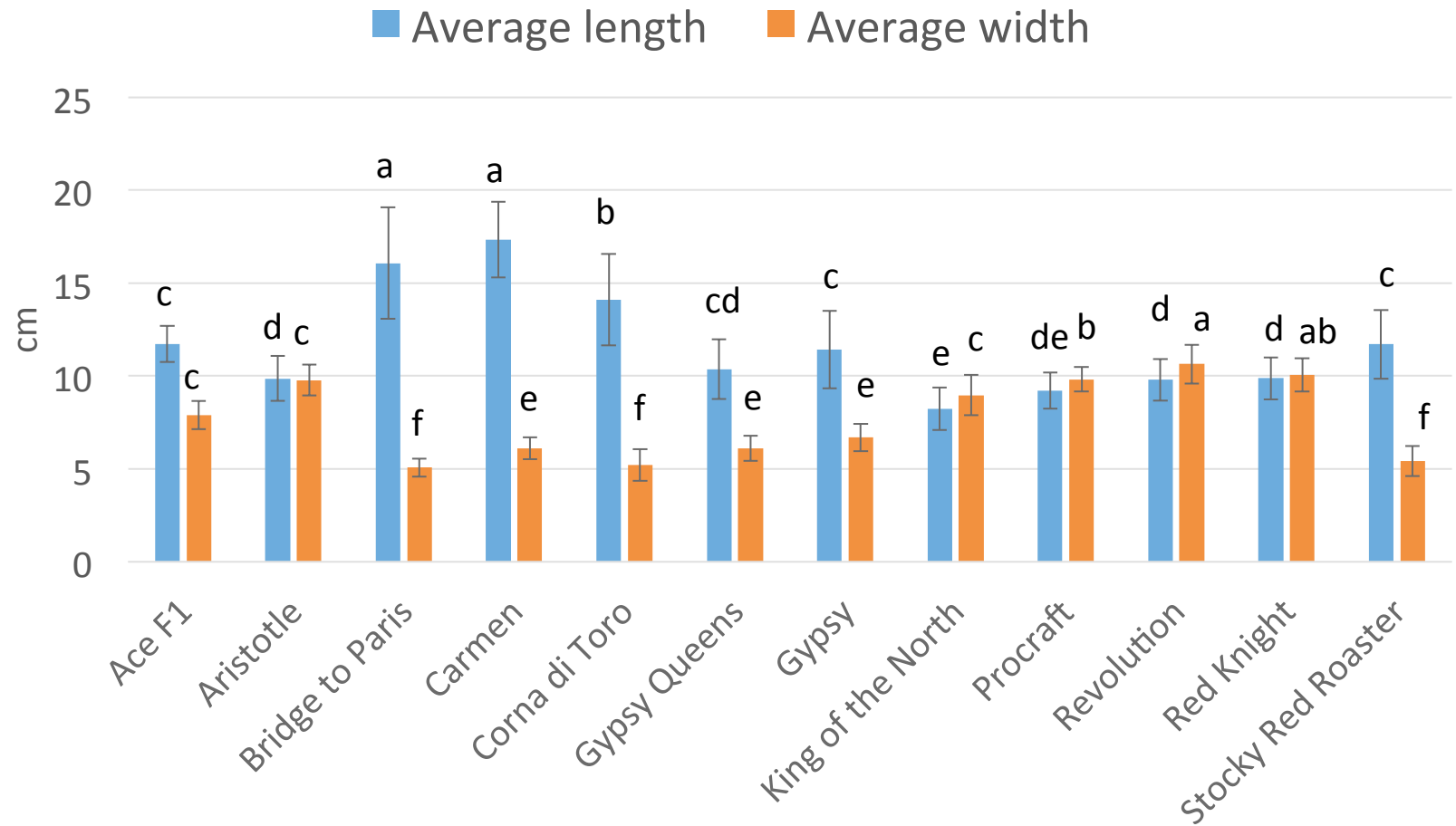


Total season marketable count per plant





Representative fruit length/width











Creating Plant Breeding Populations: Validating Research Reports for Scalability to Farm Production

**Case Study: Striped Cucumber Beetle
Management in Zucchini**

Striped Cucumber Beetle (*Acalymma vittatum*)



Utah State University, Food and Rural Initiatives



vegnet.osu.edu



westmadison.ars.wisc.edu



extension.umn.edu



msue.anr.msu.edu

Control Measures

Organic

- Row cover
- Trap cropping
- Few OMRI-approved insecticides

Control Measures

Organic

- Row cover
- Trap cropping
- Few OMRI-approved insecticides

Conventional

- Systemic neonicotinoid insecticides

Need resistant cultivars!

Market Class	Damage		Cultivar	Seed Source	Damage	
Scallop	3.0	a	Golden Bush Scallop	SO	1.0	a
			Flying Saucer	JS	2.7	a
			Yellow Scallop	SW	3.3	a
			Woods Prolific Bush Scallop	SE	5.0	a
Straightneck	3.7	a	Cougar (<i>n=9</i>)	HS	3.0	a
			Multipik	HS	3.3	ab
			Superpik	HS	3.3	a
			Early Prolific Straightneck (<i>n=14</i>)	SO	3.8	ab
			Success PM (<i>n=14</i>)	HM	5.0	ab
Acorn/ Delicata	4.3	a	Honey Bear	JS	2.0	ab
			Jester	JS	2.0	ab
			Sugar Loaf (<i>n=7</i>)	NG	2.6	ab
			Royal Ace (<i>n=14</i>)	HS	3.5	ab
			Bush Delicata	CU	4.0	a
			Zeppelin	WG	5.3	ab
			Honeyboat	OS	6.0	ab
			Sweet REBA	CU	8.7	a-c
Pumpkin	12.3	b	Racer	JS	9.4	a-c
			Triple Treat	B	9.7	a-c
			Magic Lantern	HS	11.0	a-c
			Aladdin	HS	13.7	a-d
			Howden	HS	20.0	b-e
Zucchini	34.4	c	Dunja	JS	22.0	c-e
			Reward	OS	31.7	de
			Black Beauty (<i>n=14</i>)	TS	31.7	de
			Zucchini Elite	HS	33.0	e
			Golden Zucchini	SE	53.7	f

Striped Cucumber Beetle Preference within *Cucurbita pepo*



Market Class	Striped Cucumber Beetle Risk?
Straightneck Summer Squash	<p>OK!</p> <p>Striped cucumber beetles tend to leave these plants alone</p>
Crookneck Summer Squash	
Scallop/Patty Pan Squash	
Acorn Squash	
Delicata Squash	
Jack-o'-lantern Pumpkin	<p>Be Careful!</p> <p>Striped cucumber beetles inflict moderate damage</p>
Cocozelle	
Zucchini	<p>Needs Help!</p> <p>Striped cucumber beetles LOVE these plants!</p>

Striped Cucumber Beetle Preference within *Cucurbita pepo*



C. pepo* subsp *texana

Market Class

Striped Cucumber Beetle Risk?

Straightneck Summer Squash

Crookneck Summer Squash

Scallop/Patty Pan Squash

Acorn Squash

Delicata Squash

OK!

Striped cucumber beetles tend to leave these plants alone

C. pepo* subsp *pepo

Jack-o'-lantern Pumpkin

Cocozelle

Zucchini

Be Careful!

Striped cucumber beetles inflict moderate damage

Needs Help!

Striped cucumber beetles LOVE these plants!



Breeding SCB Resistant Cultivars



Case study: Golden Zucchini

Choosing Parents

Parent 1

- **Non-preferred by striped cucumber beetles**
- **Fruit type as similar as possible to zucchini**

Parent 2

- **Right fruit type (golden zucchini) and characteristics**

Choosing Parents

Success PM Summer Squash
(*C. pepo* subsp. *texana*)



Photo: High Mowing Seeds

Golden Zucchini
(*C. pepo* subsp. *pepo*)



Photo: Harris Seeds

Choosing Parents

Success PM Summer Squash
(*C. pepo* subsp. *texana*)



Golden Zucchini
(*C. pepo* subsp. *pepo*)



Would this breeding strategy

– introgression of non-preference from
summer squash to zucchini –

**lead to a cultivar that can withstand
beetle pressure on a farm scale?**

Study System: The Parents

Success PM Summer Squash
(*C. pepo* subsp. *texana*)



Photo: High Mowing Seeds

Golden Zucchini
(*C. pepo* subsp. *pepo*)



Photo: Harris Seeds

Study System: The Parents

Success PM Summer Squash
(*C. pepo* subsp. *texana*)



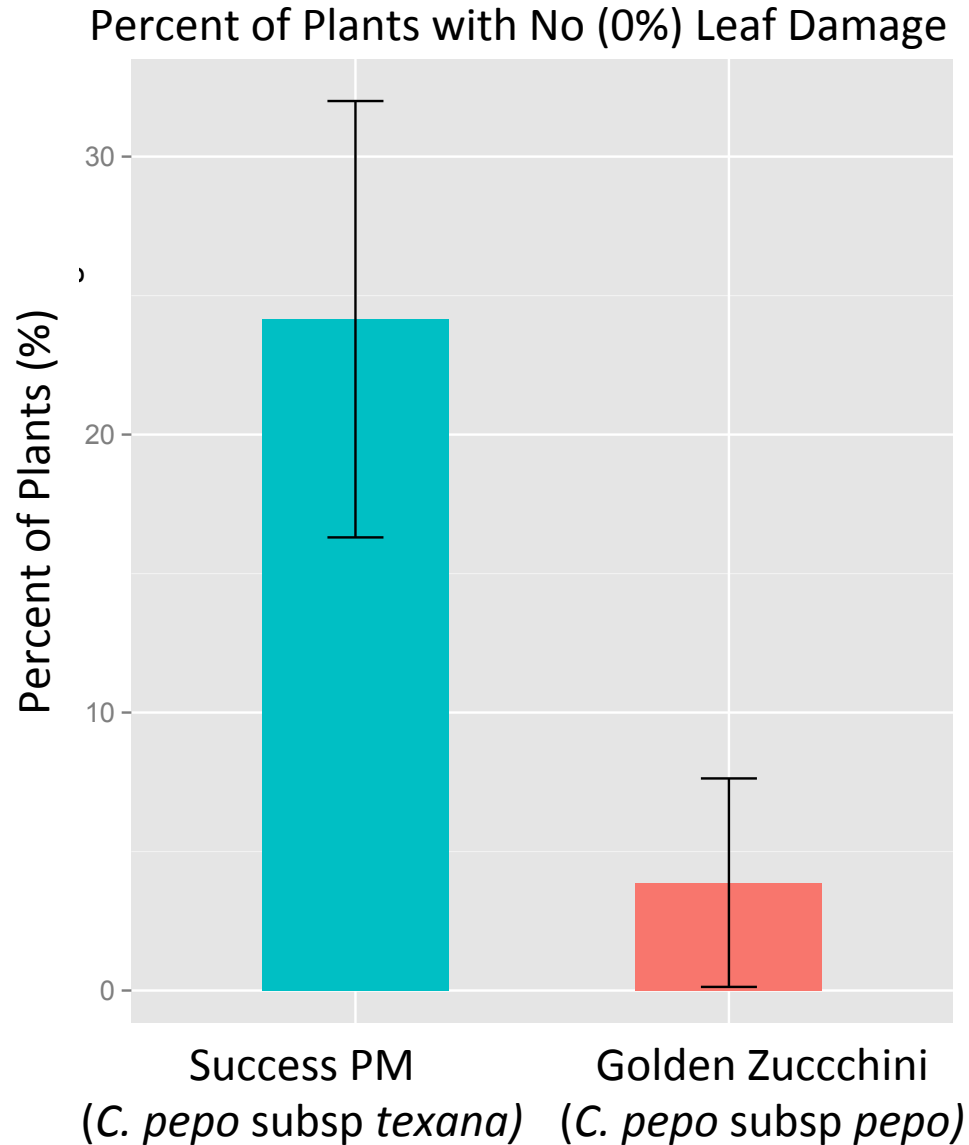
Golden Zucchini
(*C. pepo* subsp. *pepo*)



Greenhouse No Choice Trial



Greenhouse No-Choice Trial





**Pullyen and Tailby Research Farms
Varna, NY**

Success PM (non-preferred)

17 July 2015

% Leaf Damage

0
10
20
30
40
50
60
70
80
90
100

10	5	5	5	5	5	5	5	5	5	10
5	5	5	0	5	5	0	5	10	5	5
5	5	5	5	0	5	5	5	5	5	5
0	10	5	10	5	5	0	0	5	5	5
5	5		5	5	5	5	5	15	5	5
-	5	15	5	5	5	5	10	5	15	5
	5			5	5	5	5	10	10	5
5	5	5	5	5	5	5	5	5	5	5
0	5	5	5	5	5	5	5	5	5	20
0	5	10	0	0	5	5	5	5	5	5
5	5	10	5	5	5	0	5	5	5	0
5	0	0	5	5	5	5	5	5	5	5
5	5	15	5	0	5	5	5	5	5	5
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5	10	5	5	5	5	5	10	5	5	5
5	5	5	5	5	5	5	10	5	0	5
5	5	-	5	5	5	5	5	5	5	5
0	5	10	5	10	5	5	5	5	5	5
5	0	5	10	5	10	10	5	5	5	5
-	0	0	10	5	0	5	10	5	5	5
0	5	5	10	5	0	10	5	10	5	5
10	0	10	5	5	5	5	5	0	5	5
-	5	10	5	0	5	5	10	2	5	5
0	5	0	5	0	0	5	5	2	5	5
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60	10	40	50	90	40	80	20	25	60	60
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50	50	15	50	60	45	30	50	50	45	60
50	30	20	40	75	40	60	40	50	50	60
80	15	75	45	45	50	20	40	25	60	60
75	45	30	50	50	60	50	20	60	75	60
60	40	40	50	25	45	40	25	40	30	60
50	30	75	50	40	40	75	30	50	60	60
0	30	75	40	40	60	60	30	75	30	60

Golden Zucchini

(preferred)

6 July 2015

Conclusions

- **Validation of parents for plant breeding populations**
- **Organization of striped cucumber beetle preference within species**

Striped Cucumber Beetle Preference within *Cucurbita pepo*



C. pepo* subsp *texana

Market Class

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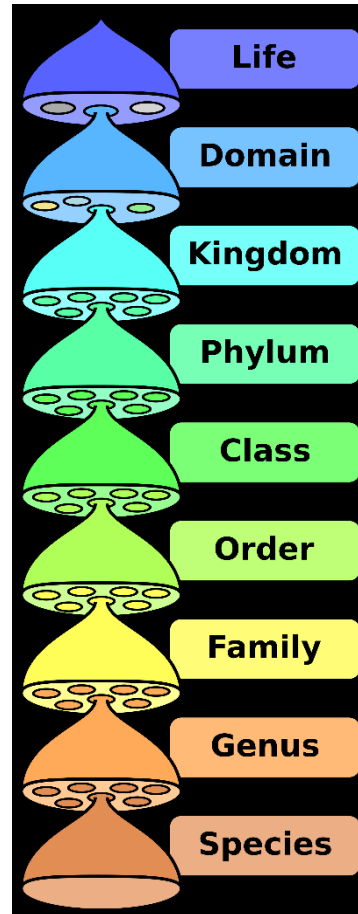
Needs Help!

Striped cucumber beetles LOVE these plants!





Know Your Crop's Genus



Search for “Cucurbita Gene List”

<i>n</i>	<i>h</i>	<i>naked</i> seeds. Lacking a lignified seed coat, <i>n</i> from oil-seed pumpkin.	<i>pepo, moschata</i>	29, 86, 107, 112, 113
<i>pl</i>		<i>plain light</i> fruit color, <i>pl</i> from ‘Beirut’ vegetable marrow and ‘Fordhook Zucchini’; <i>Pl</i> in ‘Vegetable Spaghetti’.	<i>pepo</i>	58
<i>Pm</i>		<i>Powdery mildew</i> resistance. Resistance to <i>Podosphaera xanthii</i> ; <i>Pm</i> from <i>C. lundelliana</i> .	<i>lundelliana</i>	76
<i>Pm-0</i>		<i>Powdery mildew</i> resistance. Resistance to <i>Podosphaera xanthii</i> ; <i>Pm-0</i> from <i>C. okeechobeensis</i> and in <i>C. pepo</i> .	<i>okeechobeensis, pepo</i>	11, 13, 37
<i>pm-1</i>		<i>powdery mildew</i> resistance in <i>C. moschata</i> . Series of three alleles: <i>pm-1^P</i> for susceptibility from ‘Ponca’ dominant to <i>pm-1^L</i> for resistance from ‘La Primera’, which is dominant to <i>pm-1^W</i> for susceptibility in ‘Waltham Butternut’.	<i>moschata</i>	2
<i>pm-2</i>		<i>powdery mildew</i> resistance in <i>C. moschata</i> ‘Seminole’, recessive to <i>Pm-2</i> for susceptibility	<i>moschata</i>	2

“Capsicum Gene List” Search

<i>t</i>		<i>High beta-carotene</i> ; complementary with <i>B</i>
<i>tal*</i>		<i>Tall</i> ; plant height, 65 to 80 cm; fewer branches, flowers and fruits; induced from ‘PC 1’
<i>tl</i>		<i>Taphrina leaf</i> ; leaves are deformed and rugose like peach leaves infected with <i>T. deformans</i> ; stems tend to prostrate
<i>tra</i>		<i>Transition of fruit color</i> ; fruit color transition phenotype in the jalapeño cultivar ‘NuMex Pinata’
<i>Tsw</i>		<i>Tomato spotted wilt virus resistance</i> ; resistance to TSWV in <i>C. chinense</i> PI 159236; highly effective against TSWV isolates
<i>tu</i>		<i>Tube</i> ; cotyledons and leaves are rolled up like a tube, only the abaxial surface is exposed; relationship to <i>ca</i> not determined
<i>un</i>		<i>Undulate</i> ; small dark-green leaves with undulated surface
<i>up-1, up-2</i>	<i>p, u</i>	<i>Upright pedicle and fruit orientation</i> ; fruit and pedicle are upright

Requesting PI Accessions from NPGS (GRIN)

- Cultivar – distinct plant germplasm grown in agriculture
- Line – true breeding plant germplasm that may be appropriate for use as a cultivar
- Accession – a sample of seed that was collected, can include mixture

Requesting PI Accessions from NPGS (GRIN)

- Accession – a sample of seed that was collected, can include mixture
 - Potential for disease
 - Not all individuals will have trait you seek
 - Balance benefit of request with erosion of genetic diversity collected from nature



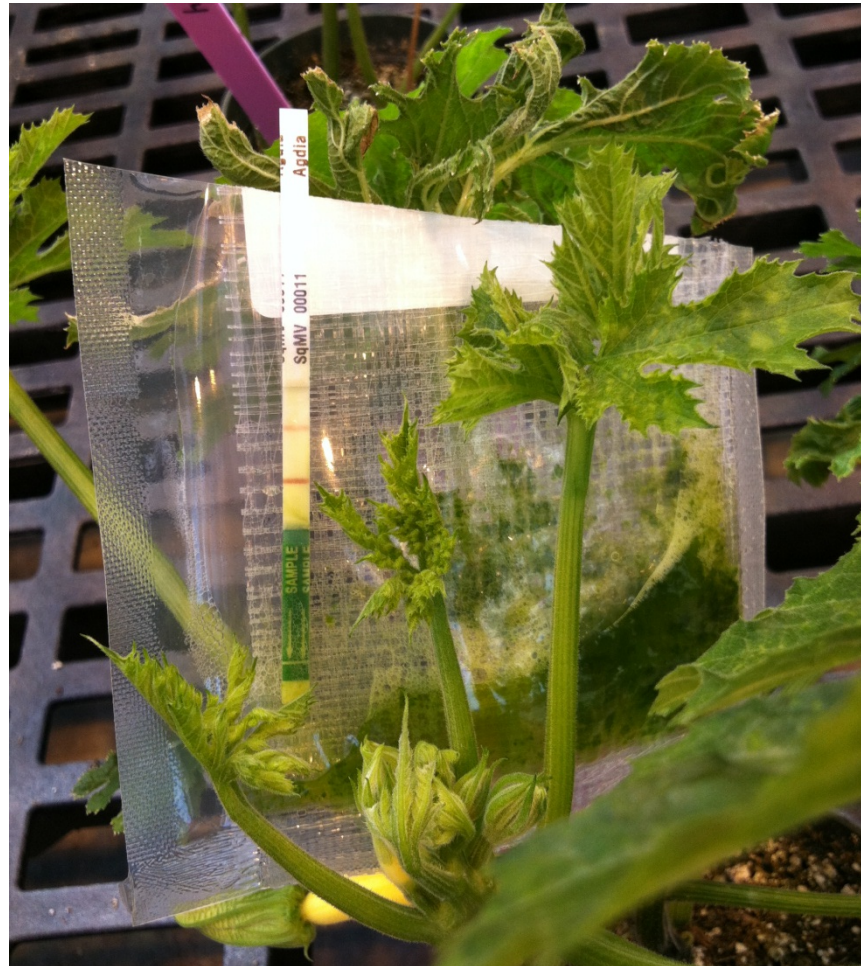
Seed Borne Disease

- www.vegetablemdonline.ppath.cornell.edu

www.agdia.com



Immunostrip Test





Mendel

- Alleles – different forms for a gene that control a trait
- Dominant allele – written in CAPITAL LETTERS
- Recessive allele – written in smalls
- True Breeding = Homozygous
- Cross dominant plant x recessive plant
 - Heterozygous offspring
 - $AA \times aa \Rightarrow Aa \text{ F1}$

Breeding with Hybrids

Dominant traits

- only needs to be inherited from one parent to appear in progeny – see it in the F1
- visible if present

Recessive traits

- needs to be inherited from both parents to appear in progeny
- plant can be an invisible carrier

Hybrid with dominant trait

- may or may not be true breeding
- Common for disease resistance

Hybrid with recessive trait

- progeny will be true breeding
- Common for domestication traits

'Amber Delight'



'Bugle' (Rupp Seeds)

X



'Honeynut' (High Mowing Seeds)



'Amber Delight'

'Amber Delight'



'Bugle' (Rupp Seeds)



'Honeynut' (High Mowing Seeds)



'Amber Delight'

Hybrid

Heterozygote for:
PMR
Some other genes
Not many others

'Amber Delight'



'Bugle' (Rupp Seeds)

PVP

Restricts:

**Saved seed for commercial use
Sale of seed of first gen hybrids**



Further generations non-restricted



'Amber Delight'

From 'Amber Delight' to '898'

'Bugle'



X



'Honeynut'



'Amber Delight'



F2 150 plants

Select plants in field for
Powdery mildew resistance
Productivity



F3 10 plants



F4 10 plants



F5 10 plants x 3 reps

Test harvested fruit for
Brix
Color
Dry matter



898

How Many Seed Should I Plant?

- **Crosses between uniform hybrids or inbreds**
 - at least 3 plants, not more than 6-10 plants
 - More if low seed yield crop
- **Self pollinations of uniform hybrids or F1's**
 - At least 3 plants, not more than 6-10 plants
 - More if low seed yield crop
- **F2 plants from selfing F1**
 - At least 16 plants
 - sweet spot between 75 and 150
 - Depends on complexity of cross (x 5 rule)

Heterozygotes and Selection

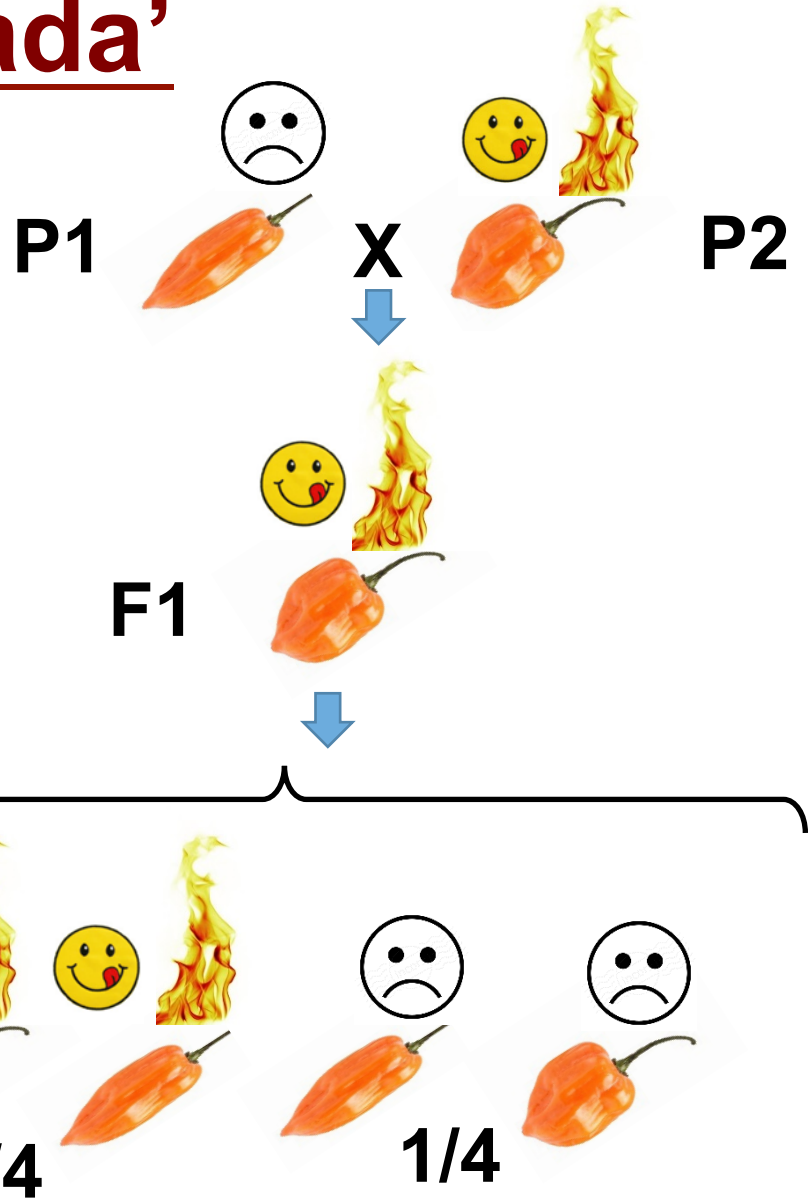
- Anthocyanins in jalapeño
- Dominant

	A	a
A	AA	Aa
a	Aa	aa

- Issue:
 - Cross green with purple
 - Discard green
 - Select best purple plant
 - Plant progeny
 - Most segregate for green



'Habanada'



'Habanada'



P1



X



P2

F1



X

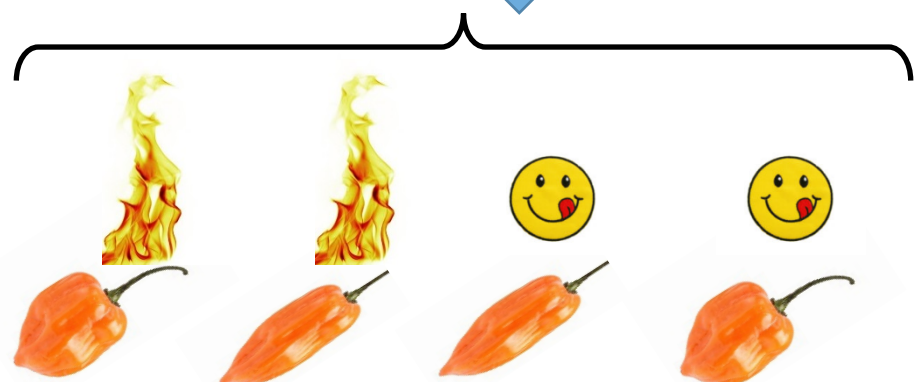
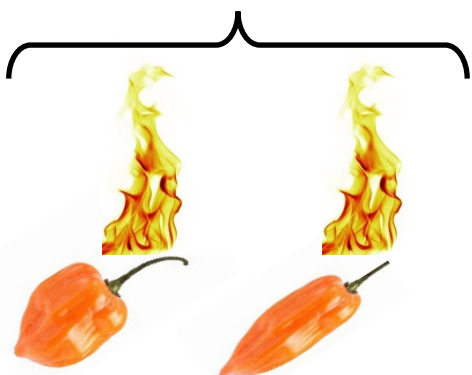


P2

BC1F1 population



BC1F2



Goal: Develop a sweet, striped (variegated) snacking pepper



Developing a sweet, striped (variegated) snacking pepper

Starting Parents:

'Fish':
spicy, variegated



'Lipstick'
sweet, non-variegated



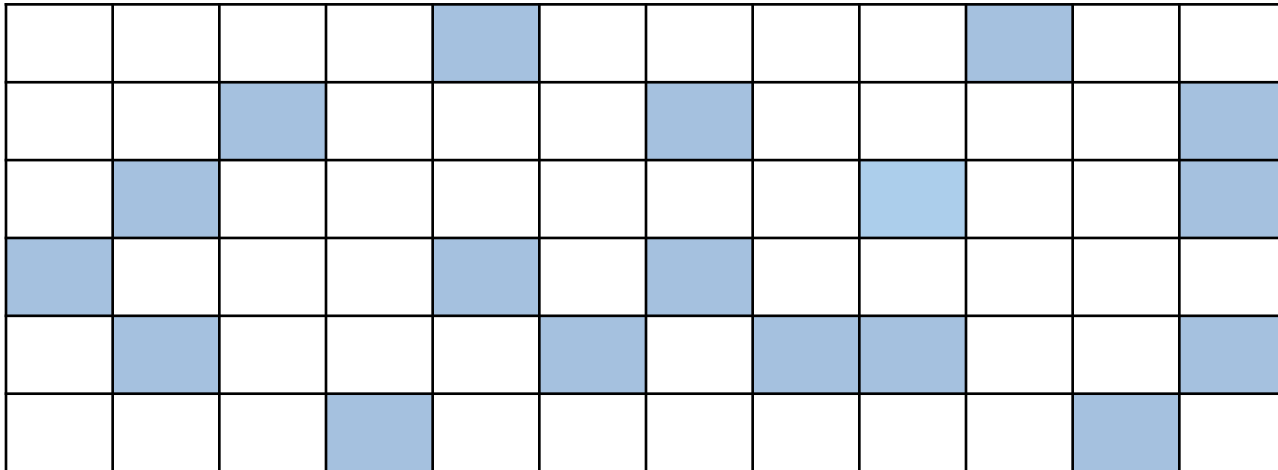
Variegated
(recessive)

X

Non-variegated
(dominant)



F1



1/4 of F2 progeny will be variegated



Acknowledgements

- Molly Jahn, Henry Munger, & Richard Robinson
- Lindsay Wyatt & Brian Leckie
- Michael Glos & Maryann Fink-Brodnicki
- Sara Shapleigh & Emily Rodekohr
- Michael Hoffmann & Jeff Gardner
- **Seed Matters**
- **Toward Sustainability Foundation**
- **USDA National Institute of Food and Agriculture**



United States Department of Agriculture
National Institute of Food and Agriculture

**Genomic And Phenomic Tools To Support Vegetable Cultivar Development:
Winter Squash As An Initial Target
USDA-AFRI 2013-67013-21232**

**Northern Organic Vegetable Improvement Collaborative
USDA-OREI 2009-51300-05585
2014-51300-22223**

**ESO-Cuc: Addressing Critical Pest Management Challenges in
Organic Cucurbit Production
USDA-OREI 2012-51300-20006**