CIOA

The Carrot Improvement for Organic Agriculture Project

Better Carrots for Organic Growers and U.S. Consumers

USDA-NIFA OREI award #2011-51300-30903

Carrot Improvement For Organic Agriculture

Project collaborators

Phil Simon (PI), USDA ARS, *University of Wisconsin Madison*

Micaela Colley, Laurie McKenzie, Jared Zystro, **Cathleen McCluskey**, *Organic Seed Alliance*

Lori Hoagland, *Purdue*

Phil Roberts, *University of California, Riverside*

Erin Silva and Jed Colquhoun, *University of Wisconsin Madison*

Joe Nunez, *University of California, Kern County Extension*

Tim Waters and Lindsey du Toit, *Washington State University*

Carrot Improvement For Organic Agriculture

Today's Webinar

- **Project introduction and overview -** Phil Simon and Micaela Colley
- **Breeding for nematode resistance** - Phil Roberts
- **Genotype x soil microbial interaction** - Lori Hoagland
- **Preliminary results** - Jared Zystro
- **CIOA website, outreach and related resources** – Cathleen McCluskey
- **Question and Answer**

Carrot Improvement For Organic Agriculture

Who needs better carrots?

14.3% of the U.S. carrot crop is in organic systems

Organic growers & Consumers

- Orange & novel colors
- Disease & pest resistance
  - Nematodes
  - Leaf blights
- Weed competitive
  - Early vigor
  - Canopy size

- Colorful – convenient - crunchy
- Culinary Quality
  - Sweet
  - Not harsh (turpentiney, "bitter")
  - Succulent
- Nutritional Quality

CIOA: The Carrot Improvement for Organic Agriculture Project

- **Information for growers and consumers** – variety trials, production information
- **Related research activities** – nematode resistance, soil microbial analysis, production systems research (organic and conventional paired trials)
- **Germplasm development** – breeding for organic systems

Carrot Improvement For Organic Agriculture

Field trials – CA, IN, WA, WI – Four Years

Organic and conventional paired management trials

36 entries – *16 cultivars, 20 breeding stocks*

- **WI: Erin Silva** summer crop
  - Center for Integrated Agricultural Systems and Department of Plant Pathology, University of Wisconsin, Madison, WI
- **IN: Lori Hoagland** summer crop
  - Department of Horticulture & Landscape Architecture, Purdue University, West Lafayette, IN
- **WA: Tim Waters** summer crop
  - Area Extension, Commercial Vegetables, Washington State University, Pasco, WA
- **CA: Joe Nunez** winter crop
  - University of California Cooperative Extension, Farm and Home, Bakersfield CA

Carrot Improvement For Organic Agriculture

Evaluation traits:

- Root yield
- Appearance
- Flavor – sweetness, harsh flavor
- Nutritional value – carotenoids, anthocyanins, nitrates
- Foliar disease resistance
- Root-knot nematode resistance
- Soil quality and carrot growth
- Top size - weed competition

Carrot Improvement For Organic Agriculture

Carrot Improvement For Organic Agriculture

Field Evaluation

PURDUE UNIVERSITY · THE UNIVERSITY OF WISCONSIN MADISON · ORGANIC seed ALLIANCE · UC RIVERSIDE · WASHINGTON STATE UNIVERSITY · Agricultural Research Service USDA · USDA United States Department of Agriculture National Institute of Food and Agriculture

Carrot Improvement For Organic Agriculture

PURDUE UNIVERSITY · THE UNIVERSITY OF WISCONSIN MADISON · ORGANIC seed ALLIANCE · UC RIVERSIDE · WASHINGTON STATE UNIVERSITY · Agricultural Research Service USDA · USDA United States Department of Agriculture National Institute of Food and Agriculture

Carrot Improvement For Organic Agriculture

Carrot cultivars included in the CIOA project

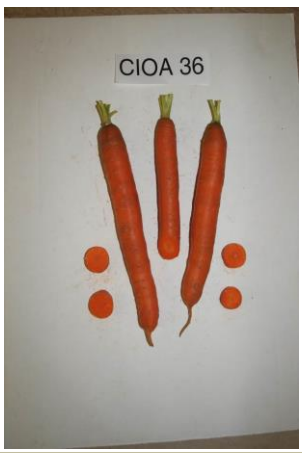
- Bolero
- Brasilia
- Creampak*
- Hilmar
- Karotan
- Napoli
- Nelson
- Purple Haze*
- Red Core Chantenay
- Rumba
- Spring Market
- SugarSnax
- Sun 255
- Upper Cut
- Western Red
- Yellow Stone*

*Not included year 1

Carrot Improvement For Organic Agriculture

Carrots in the CIOA project – cultivars

Red Core Chantenay **Bolero** **Western Red**



Carrot Improvement For Organic Agriculture

Carrots in the CIOA project – cultivars

Brasilia **Sun 255** **SugarSnax**

Carrot Improvement For Organic Agriculture

Carrots in the CIOA project – experimentals

R6637 **Y8519** **Nb8524**

Carrot Improvement For Organic Agriculture

Carrots in the CIOA project –

experimentals

P1128

P6306

P0191

Carrot Improvement For Organic Agriculture

Research related to CIOA traits of interest to growers

- Root yield
- Appearance
- Flavor
- Nutritional value
- **Foliar disease resistance**
- **Root-knot nematode resistance**
- **Soil quality and carrot growth**
- **Top size - weed competition**

Carrot Improvement For Organic Agriculture

Evaluation of foliar diseases

- **Lindsey du Toit**
  - Washington State University, Mount Vernon, WA
- Foliar disease diagnosis for samples from CA, IN, WA, WI
  - Alternaria and Cercospora leaf blights, Xanthomonas bacterial blight, and powdery mildew observed
- **Pamela Moreno – Univ. Wisc. Grad student**
  - Alternaria leaf blight resistance from new genetic sources

Carrot Improvement For Organic Agriculture

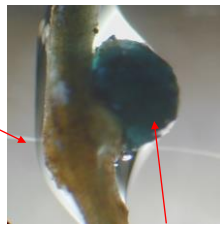
Root-knot Nematode Resistance Breeding in Carrots

Phil Roberts

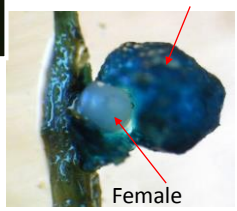
Department of Nematology

University of California - Riverside

Root-Knot Nematode Reproduction and Root Galling



Egg Mass



Carrot Improvement For Organic Agriculture

Sources of resistance to root-knot nematodes (*Meloidgyne* spp.)

Brasilia-1252 (*Mj-1*, dominant, + *Mi genes*)

R to *M. javanica* and *M. incognita*

(Br-1252 x USDA inbreds)

Non-Brasilia:

Homs – High *M. incognita* resistance

***M. javancia* resistance**

Ping Ding; Scarlet Fancy x Favourite; Western Red, Scarlet Nantes; Gold King Cross

R x R: Br 1091 x Homs; SFF x Homs

Carrot Improvement For Organic Agriculture

Root-knot nematodes (*Meloidgyne* spp.)

- Challenge of variability for response to resistance
  - Variation between main species
  - Variation within species

- 45 isolates
- *M. incognita* -- 25
- *M. javanica* -- 7
- *M. arenaria* -- 2
- *M. hapla* -- 11

Carrot Improvement For Organic Agriculture

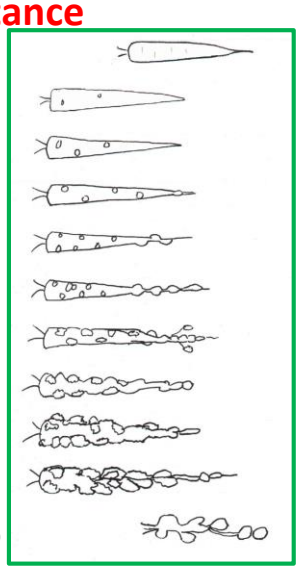
Greenhouse resistance screening

Carrot Improvement For Organic Agriculture

Greenhouse resistance screening

Carrot Improvement For Organic Agriculture

Field screens to assess resistance



C I O A Carrot Improvement For Organic Agriculture

South Coast REC Field Day & Trial Assays November 2014

PURDUE UNIVERSITY · WISCONSIN · ORGANIC seed ALLIANCE · UC RIVERSIDE · WASHINGTON STATE UNIVERSITY · Agricultural Research Service USDA · USDA

C I O A Carrot Improvement For Organic Agriculture

South Coast REC Field Day & Trial Assays

Direct involvement of seed companies

Screen USDA & seed industry breeding lines

PURDUE UNIVERSITY · WISCONSIN · ORGANIC seed ALLIANCE · UC RIVERSIDE · WASHINGTON STATE UNIVERSITY · Agricultural Research Service USDA · USDA

Carrot Improvement For Organic Agriculture

UC Field Site Evaluations for Root-Knot Nematode Resistance in 2014

Site	Location	Root-knot isolate
South Coast Res. & Extn. Center (SCREC)	Irvine (Orange Co.)	*M. incognita*
South Coast Res. & Extn. Center (SCREC)	Irvine (Orange Co.)	*M. javanica*

1,600 plots; roots selected
-- 61% (inbreds) - 70% (advanced) of *M. incognita* plots with good resistance (scores < 2)
-- 7 new inbreds released

Carrot Improvement For Organic Agriculture

South Coast REC Field Day & Trial Assays November 2014

Carrot Improvement For Organic Agriculture

Kearney REC Field Day & Trial Assays
September 2013 - Parlier

Carrot Improvement For Organic Agriculture

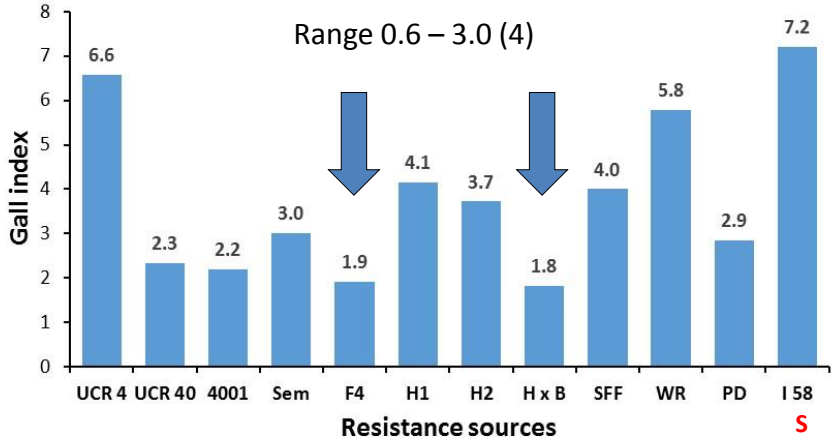
Resistant lines with good agronomic traits

3-way hybrid

Advanced breeding line

Carrot Improvement For Organic Agriculture

M. incognita -- 25 isolates



Carrot Improvement For Organic Agriculture

Summary Points

- Carrots highly susceptible to root-knot nematodes
- Excellent sources of resistance available
  - Broadly affective
  - Gaining knowledge of genomic organization for developing molecular markers
  - Resistant varieties available in near future
- Long-term investment – organic & conventional
- Team effort essential

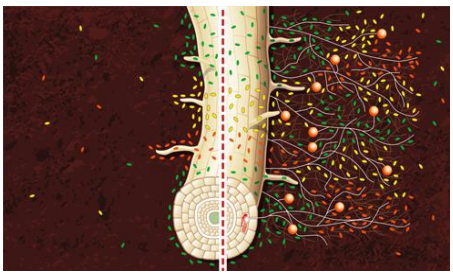
Genotype x soil microbial interaction

Lori Hoagland
Assistant Professor
Purdue University

Carrot Improvement For Organic Agriculture

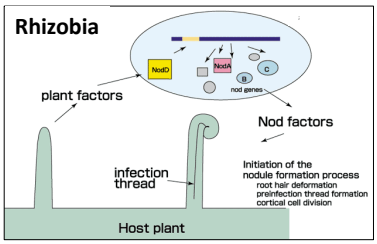
The root microbiome

- **Definition:** The dynamic community of microbes associated with the plant root
- Microbes greatly outnumber plant cells – 2nd genome
- Implications for plants
  - Nutrient acquisition
  - Biotic and abiotic stress
  - Physiological processes (ex. flowering)
  - Fruit quality

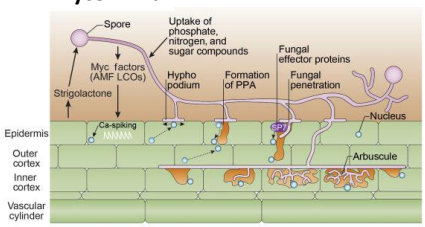


Factors affecting microbial community assembly

- Colonization is the result of carefully orchestrated processes
  - ex. Rhizobia and Mycorrhiza
- Plants
  - Species
  - Genotype
- Resident soil microbial community structure
  - Soil type
  - Land-use practices



Mycorrhiza



(Haage and Parniske, 2013)

Carrot Improvement For Organic Agriculture

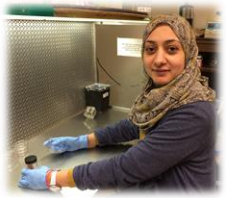
Learning more about plant-microbial relationships

- Carrot - ideal model crop
- Crop Systems Trial (GxExM)
  - 36 genotypes (G)
  - 4 environments (E)
  - 2 management systems (M)
- Approach:
  1) characterize soil quality in all environments and systems
  2) identify the composition and function in nine genotypes in Indiana crop systems trial

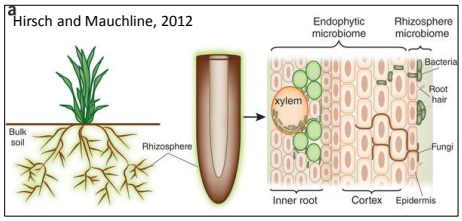
Purdue University · University of Wisconsin · Organic Seed Alliance · UC Riverside · Washington State University · ARS Agricultural Research Service · USDA · USDA National Institute of Food and Agriculture

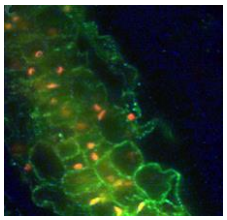
Inside the carrot root microbiome

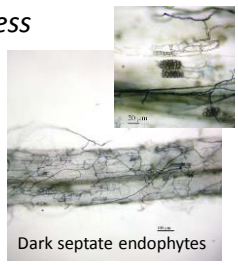
- Pathogen suppression
- Endophytes
  - more host specific than rhizosphere microbes
  - genotype specific
  - conserved across environments and physiological stages
  - most thought to be mutalistic
  - most viable but not culturable – *induced under stress*



Dr. Sahar Abdelrazek



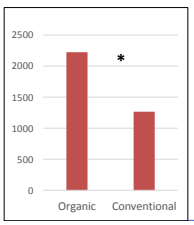




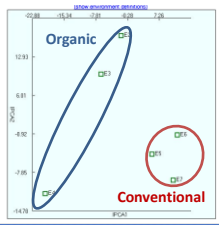
Carrot Improvement For Organic Agriculture

Preliminary results – 2014

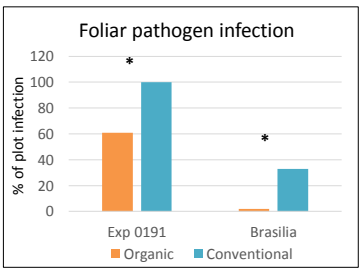
- Soil microbial biomass and activity greater in organic
- Soil microbial community structure differed between systems
- No difference in carrot yield
- Foliar pathogen infection greater in conventional system in two genotypes



IN Soil microbial biomass

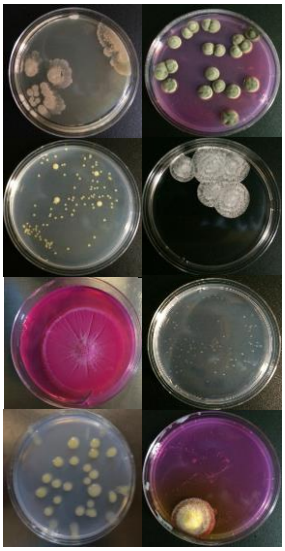


IN Fungal community structure



Carrot Improvement For Organic Agriculture

Preliminary results - Culturable endophyte diversity



	Conventional	Organic
Fungi	Uncultured Cladosporium	-
Fungi	***Clamidosporum cladosporioides***	***Clamidosporum cladosporioies***
Fungi	-	Uncultured Ascomycota/Epicoccum spp.
Fungi	-	Uncultured Phyllachoraceae/Colletotrichum
Fungi	-	*Colletotrichum coccodes*
Fungi	-	Uncultured Engyodontium spp.
Bacteria	-	Uncultured Stenotrophomonas spp.
Bacteria	***Stenotrophomonas maltophila***	***Stenotrophomonas maltophilia***
Bacteria	**Uncultured Xanthomonas spp.**	**Uncultured Xanthomonas spp.**
Bacteria	***Xanthomonas oryzae***	***Xanthomonas oryzae***
Bacteria	*Xanthomonas campestris*	-
Bacteria	*Bacillus megabacterium*	-
Bacteria	-	Paenibacillus spp.
Bacteria	*Rhizobium etli*	-
Bacteria	-	*Rhizobium giardinii*
Bacteria	-	Methylobacterium spp.
Bacteria	-	Uncultured Pseudomonas spp. (***2 – distinct isolates***)
Bacteria	-	*Pseudomonas flourescens* (***3 – distinct isolates***)
Bacteria	-	*Pseudomonas oleovorans*
Bacteria	-	*Pseudomonas brassicacearum*

Carrot Improvement For Organic Agriculture

Preliminary results - Culturable endophyte abundance

Exp 0191 - Asia

Exp 6306 Asia

Exp 0252 Svria

Exp 8519 Turkey

Exp 3999 Brazil/Europe

Karotan - Europe

Scarlet Fancy X Favorite – U.S.

Brasilia - Brazil

Red Core Chantenay - Europe

Count on R2A media for oligotrophic bacteria

Entry	Conventional	Organic
Exp 0191 - Asia	3 X 10^3	2.2 X 10^{10}
Exp 6306 - Asia	2.75 X 10^4	8.0 X 10^9
Exp 0252 - Syria	1.0 X 10^2	*too many to count*
Exp 8519 - Turkey	2.1 X 10^4	2.0 X 10^8
Exp 3999 – Brazil/Europe	8.12 X 10^7	2.0 X 10^8
Karotan - Europe	4.3 X 10^3	4.5 X 10^8
Scarlet Fancy X Favorite – United States	1.9 X 10^5	4.5 X 10^8
Brasilia - Brazil	1.8 X 10^5	2.0 X 10^8
Red Core Chantenay - Euorpe	1.3 X 10^3	6.5X 10^8

On-going experiments

- What can the culturable isolates do?
  - phytohormone production?
  - antibiotic production?
  - nutrient acquisition?
- What else is living inside these roots?
  - culture-independent community profiling
- Can they help the plant withstand soil-borne and foliar diseases?
- How does the plant and endophyte communities respond in the presence of a pathogen?

https://c2.staticflickr.com/8/7299/12196768065_15eec17026_b.jpg

Carrot Improvement For Organic Agriculture

Conclusions and future directions

- Plant-microbial relationships are specific and have significant implications for crop productivity
- Microbes are abundant in carrot roots
- Identify superior microbial isolates for seed inoculants
- Integrate selection for beneficial plant-microbial relationships in breeding programs

http://www.dreamstime.com/royalty-free-stock-image-marmot-eating-image20997486

Carrot Improvement For Organic Agriculture

Preliminary results from 2011 and 2012 CIOA field trials

Jared Zystro

Organic Seed Alliance

Carrot Improvement For Organic Agriculture

Methods

- Trials grown in 2011 and 2012
- California, Washington, Wisconsin, and Indiana
- Paired organic and conventional systems
- 36 entries
- Randomized complete block design (RCBD) with three replications.

Traits

- Plant width
- Plant height
- Root weight
- Top weight
- Harshness
- Sweetness

Carrot Improvement For Organic Agriculture

Analysis

- Analysis of variance (ANOVA)
- Means, based on Best Linear Unbiased Estimators (BLUEs)
- Spearman rank correlations
- Kang's stability statistic

Results

- Differences between entries for top height and width, top mass, root weight, sweetness, and harshness.

Carrot Improvement For Organic Agriculture

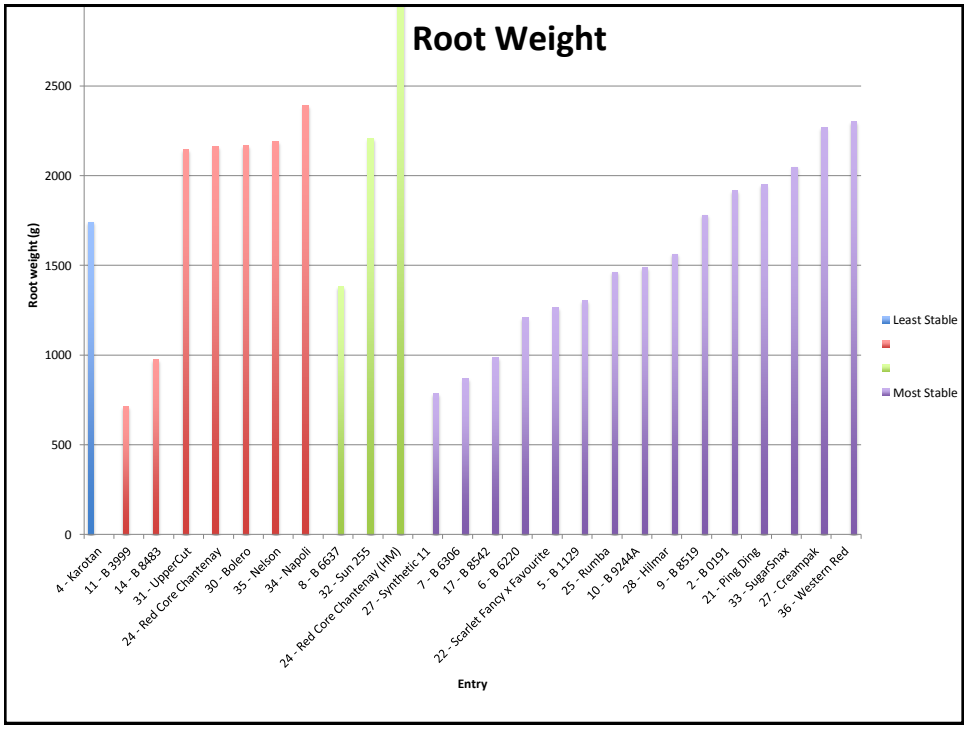
Results

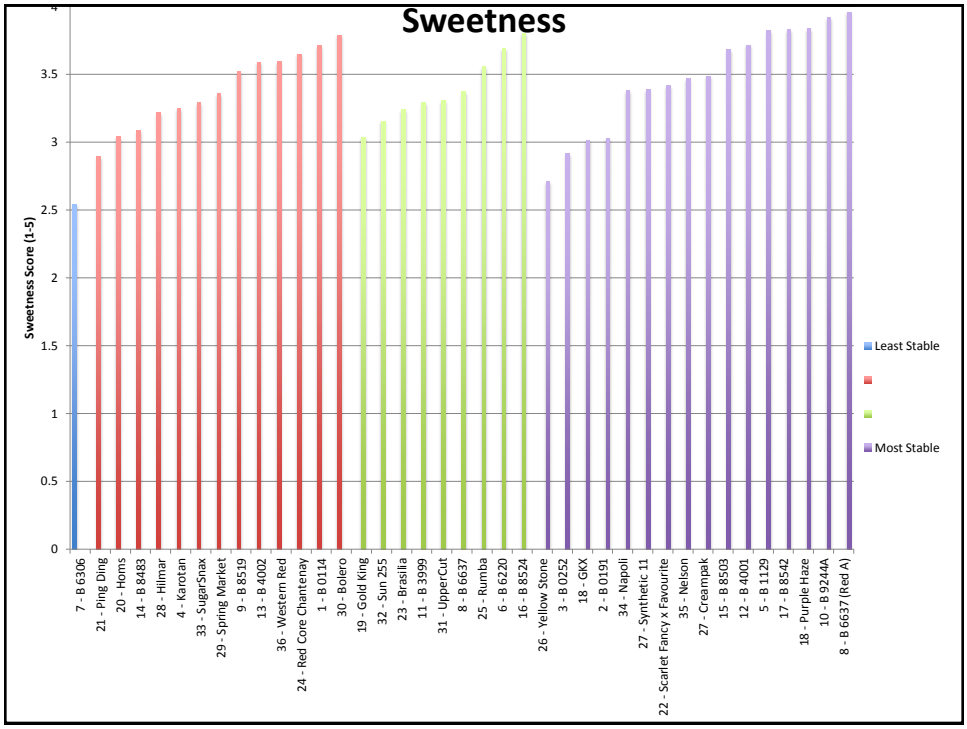
- Entry ranks not always consistent between different years or locations.
- Entry ranks generally consistent between paired organic and conventional systems in same year and location

Carrot Improvement For Organic Agriculture

Results

- Some entries performed more consistently across environments than others.





C I O A **Carrot Improvement For Organic Agriculture**

CIOA Online Resources

Website

Searchable Gallery

Organic Variety Trial Database

Cathleen McCluskey, Organic Seed Alliance, cathleen@seedalliance.org

PURDUE UNIVERSITY · WISCONSIN · ORGANIC seed ALLIANCE · UC RIVERSIDE · WASHINGTON STATE UNIVERSITY · Agricultural Research Service · USDA · USDA

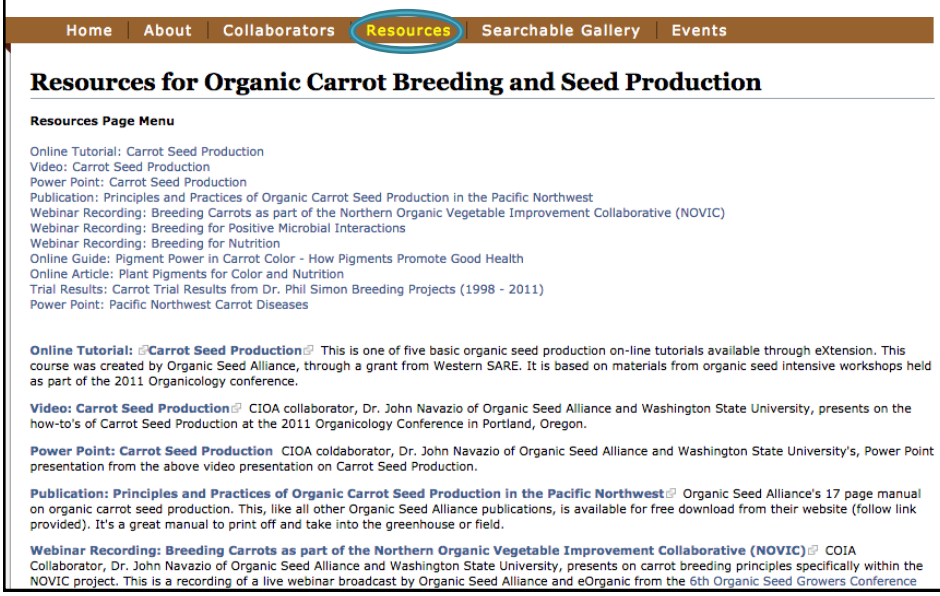
Carrot Improvement For Organic Agriculture

Website

http://eorganic.info/group/7645

Carrot Improvement For Organic Agriculture

Resources



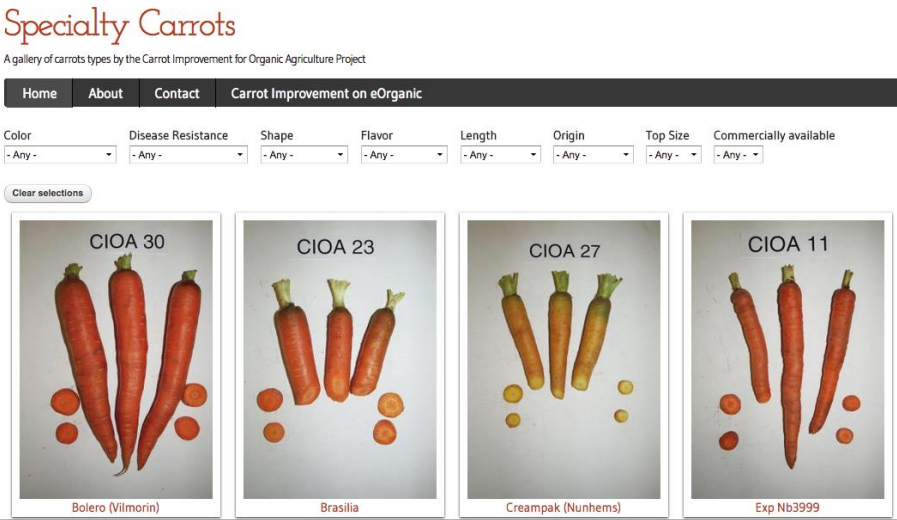
Carrot Improvement For Organic Agriculture

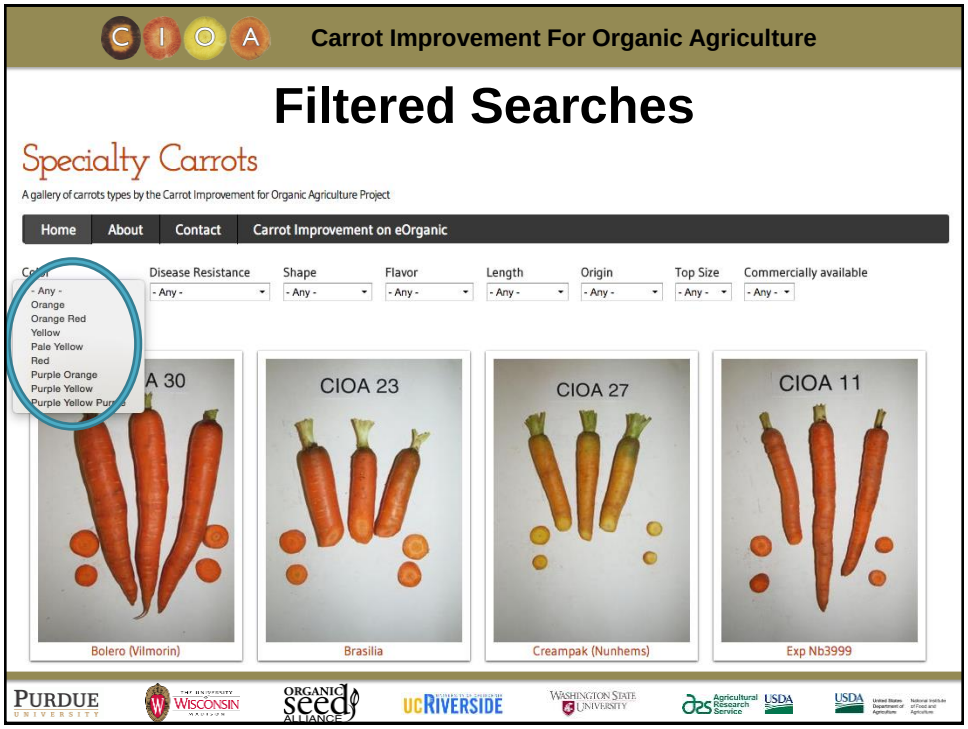
Searchable Gallery

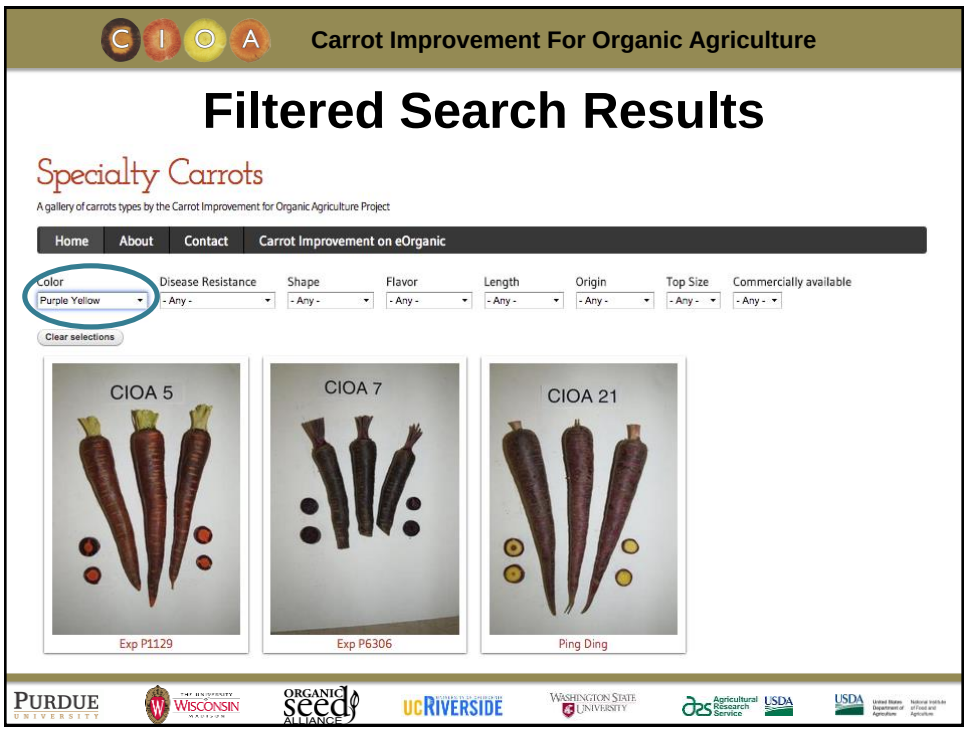
Carrot Improvement For Organic Agriculture

Searchable Gallery

http://carrots.eorganic.info/




Carrot Improvement For Organic Agriculture
Filtered Searches
Specialty Carrots
A gallery of carrots types by the Carrot Improvement for Organic Agriculture Project
Home
About
Contact
Carrot Improvement on eOrganic
Color
- Any -
Orange
Orange Red
Yellow
Pale Yellow
Red
Purple Orange
Purple Yellow
Disease Resistance
Shape
Flavor
Length
Origin
Top Size
Commercially available
CIOA 23
CIOA 27
CIOA 11
Bolero (Vilmorin)
Brasilia
Creampak (Nunhems)
Exp Nb3999
PURDUE
WISCONSIN
ORGANIC seed ALLIANCE
UCRIVERSIDE
WASHINGTON STATE UNIVERSITY
Agricultural Research Service
USDA


Carrot Improvement For Organic Agriculture
Filtered Search Results
Specialty Carrots
A gallery of carrots types by the Carrot Improvement for Organic Agriculture Project
Home
About
Contact
Carrot Improvement on eOrganic
Color
Purple Yellow
Disease Resistance
Shape
Flavor
Length
Origin
Top Size
Commercially available
Clear selections
CIOA 5
CIOA 7
CIOA 21
Exp P1129
Exp P6306
Ping Ding
PURDUE
WISCONSIN
ORGANIC seed ALLIANCE
UCRIVERSIDE
WASHINGTON STATE UNIVERSITY
Agricultural Research Service
USDA

Carrot Improvement For Organic Agriculture

Specialty Carrots

A gallery of carrots types by the Carrot Improvement for Organic Agriculture Project

Home | About | Contact | Carrot Improvement on eOrganic

Ping Ding

Origin: China
Length: Medium
Shape: Conical
Top Size: Medium
Flavor: Below Average
Color: Purple OrangePurple Yellow
Commercially available: No

Carrot Improvement For Organic Agriculture

Organic Variety Trial Database

Home | About | Collaborators | Resources | Searchable Gallery | Events

Carrot Improvement for Organic Agriculture (CIOA) is a long-term breeding project that addresses the critical needs of organic carrot farmers by developing orange and novel colored carrots with improved disease and nematode resistance, improved weed competitiveness, and improved nutritional value and flavor. This four-year project will also compare the relative performance of breeding... Read more

Searchable Gallery

Resources

Organic Variety Trial Database

News

Carrot Country -- Winter 2012

National Project to Improve Organic Production Systems Launched

Events

MAR 24 2015

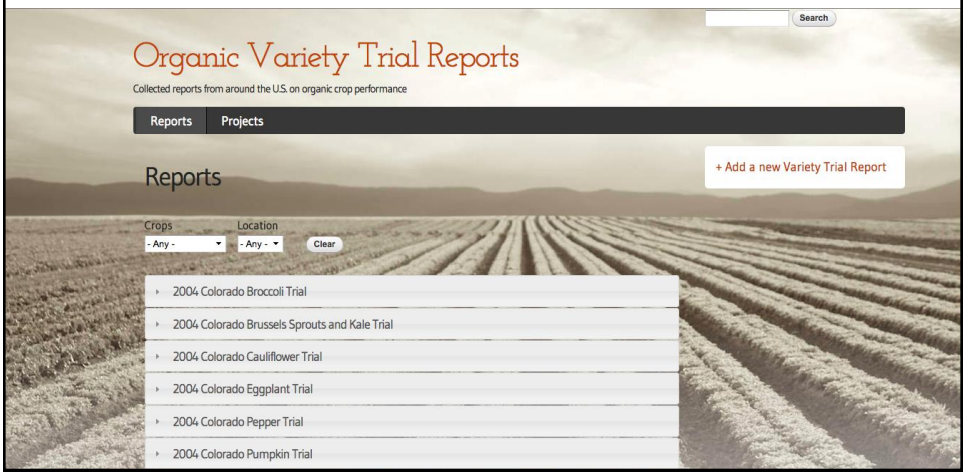
Carrot Improvement for Organic Agriculture Webinar

Join eOrganic for this free webinar to learn about the Carrot Improvement for Organic Agriculture project on March 24, 2015.

Carrot Improvement For Organic Agriculture

Organic Variety Trial Database

http://varietytrials.eorganic.info/

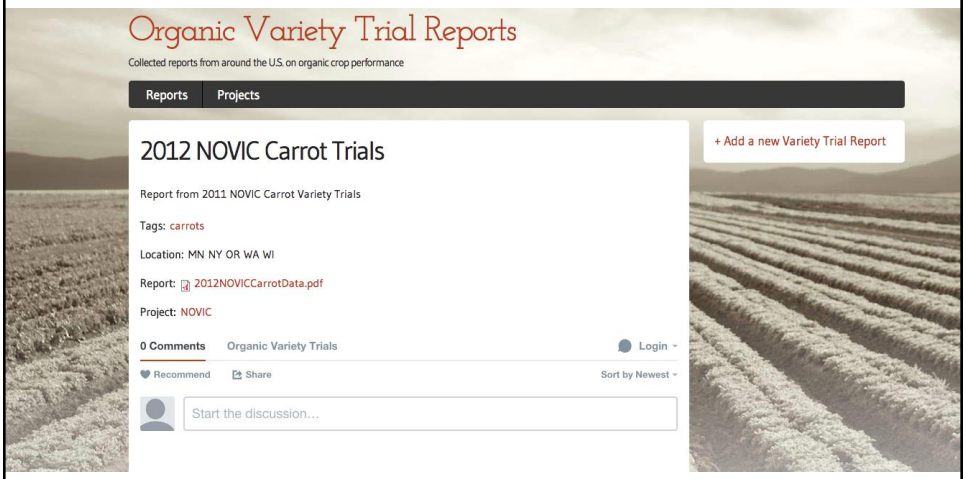


Carrot Improvement For Organic Agriculture

Filtered Searches

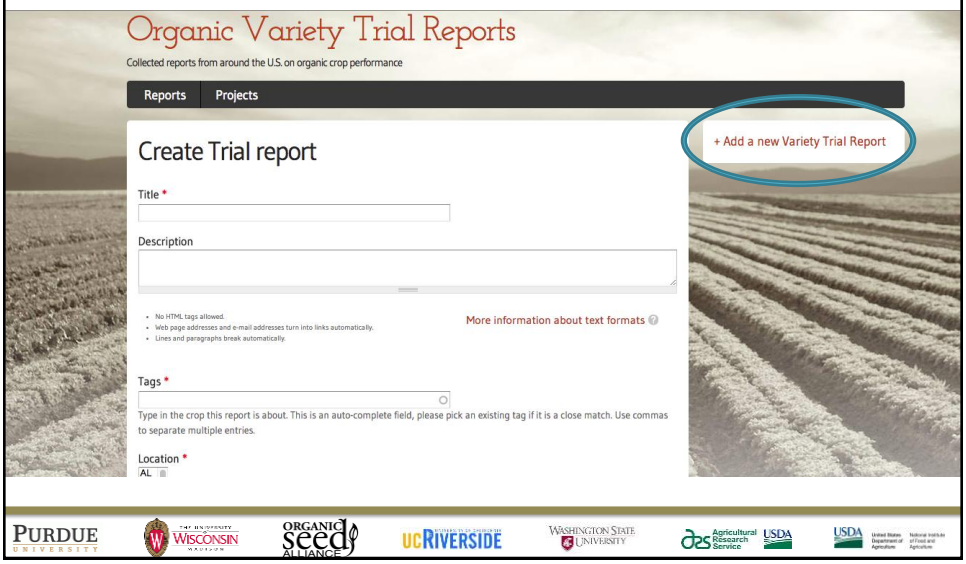
Carrot Improvement For Organic Agriculture

Filtered Search Results



Carrot Improvement For Organic Agriculture

Add Trial Reports



Carrot Improvement For Organic Agriculture

Questions and Feedback

Cathleen McCluskey
cathleen@seedalliance.org
(360) 472-0247