Carrot Improvement for Organic Agriculture (CIOA): Leveraging On-Farm and Below Ground Networks

BACKGROUND

Carrots are an economically important crop for organic specialty crop farmers, with 12% of US carrot acreage under organic management bringing more than $120 million in farmgate sales. Yet, challenges with organic weed and disease management and a lack of cultivars with desired market traits limit organic producers' capacity to take full advantage of the market potential.

Since its launch in 2011, the Carrot Improvement for Organic Agriculture (CIOA) project, led by Phillip Simon and researchers at the University of Wisconsin-Madison, has established a robust nationwide network of plant breeders, organic farmers, and small-scale seed companies to develop and release new carrot varieties better suited to organic systems.

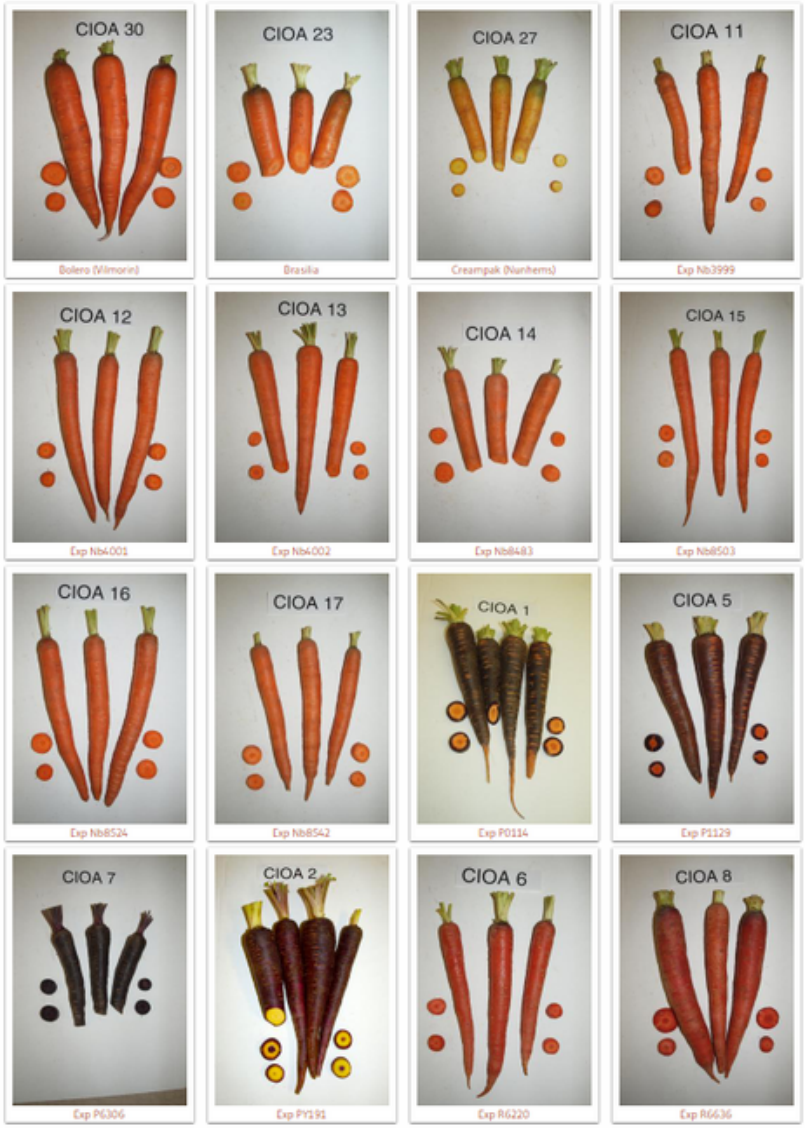
WHAT IS THE RESEARCH ABOUT?

The CIOA project received its third grant from the Organic Research and Extension Initiative (OREI) in 2021 to continue with this important work.

The objectives of this third grant project were to 1) expand the farmer participatory carrot breeding network, 2) speed the release of additional cultivars, and 3) examine the link between carrot genetics and the composition and function of microbial communities (or microbiomes) within carrot root tissue (endophytic) and the root zone (rhizosphere).

The research looks at how interactions with soil microbes influence resistance to Alternaria leaf spot (ALS) and root knot nematodes (RKN); seedling vigor and competitiveness against weeds; exclusion of heavy metal uptake; and market traits such as flavor, nutritional value, and diverse colors.

Carrot growers can enhance resilience to biotic and abiotic stresses and reduce the need for off-farm inputs by selecting carrot varieties that associate effectively with soil microbes.



A gallery of carrot types by the Carrot Improvement for Organic Agriculture Project
Source: https://eorganic.info/carrotimprovement

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PROJECT OBJECTIVES AND APPROACH

Variety development and release
In 2022, 5 organic seed companies evaluated 3 improved carrot varieties to determine interest in commercialization. One is now available commercially from High Mowing Organic Seeds under the name 'Carnelian'. Other releases are advancing to commercialization.

Expand participatory variety trial and plant breeding network
The online platform SeedLinked was used to collect and share trial evaluation, informing new variety releases. The project expanded its collaboration with farmers across the US through its partnership with the Organic Seed Alliance (OSA) where at least 40 farms per year participate in decentralized on-farm variety trials.

'Carnelian' carrot
Source: https://www.highmowingseeds.com/organic-non-gmo-carnelian-carrot.html

Examine links between microbiomes, nutrient uptake, disease resistance & quality in carrot varieties
One study in this project looked at how microbiomes in carrot taproots differ among cropping systems and regions and whether this influences crop yield and quality. Another explored the relationships between carrot root exudates, soil microbiome characteristics, and carrot quality.

Utilize molecular markers to improve nematode resistance
Molecular markers are being developed to confirm the identity of resistance genes in breeding stocks.

Evaluate and improve carrot flavor, texture and color
Assessment of carrot flavor was integrated into all breeding activities since flavor is a priority trait necessary for the successful adoption of new varieties.

KEY TAKEAWAYS

- Understanding the link between on-farm practices, carrot genetics, and microbial life could help growers maximize productivity and land stewardship.

- Carrot taproots have the potential to be colonized by an abundant and diverse assortment of bacteria and fungi.
  - These endophytes can play an important role in mediating disease resistance and nutrient availability, and it may be possible to select for these beneficial plant-microbial relationships in carrot breeding programs, resulting in varieties ideally suited to organic farming systems.

- Implementing soil-building practices commonly used in organic farming systems has the potential to promote these beneficial relationships and improve the health and productivity of carrot crops.
  - Soils in organic systems often have greater total organic matter, microbial biomass, and activity than in conventional systems.
  - Microbial populations found in organic carrot roots (endophytes) may be more antagonistic against diseases like Alternaria root rot.

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KEY TAKEAWAYS, CONTINUED

- Carrot variety makes a difference.
  - Variety affects endophyte abundance and the potential for microbial populations to influence seed germination, seedling growth and disease tolerance.
  - Carrot varieties differ in their potential to alter soil bacterial communities and stimulate microbially-mediated decomposition of organic materials, influencing nutrient availability and heavy metal uptake in the field.

- Farmer participatory plant breeding continues to make progress toward new cultivars that combine priority agronomic and market traits. Advanced breeding lines include:
  - Orange varieties with excellent flavor and resistance to RKN, ALS, and cavity spot disease,
  - A new purple line with resistance to northern RKN,
  - Purple, red, and yellow lines with improved flavor, texture, and agronomic traits.

Advanced breeding lines from the CIOA breeding project
Source: https://www.purdue.edu/hla/sites/hoaglandlab/projects/h text

This project is ongoing, and more research results will be coming!

Learn more about the CIOA project, get involved, stay up to date with new variety releases, and find grower resources at:

https://eorganic.info/carrotimprovement

RESOURCES AND LINKS

Triviño, N.J., Rodriguez-Sanchez, A., Filley, T. et al. (2023) Carrot genotypes differentially alter soil bacterial communities and decomposition of plant residue in soil. Plant Soil 486, 587–606. https://doi.org/10.1007/s11104-023-05892-0

Abdelrazek S, Simon P, Colley M, Mengiste T, Hoagland L. (2020) Crop management system and carrot genotype affect endophyte composition and Alternaria dauci suppression. PLoS ONE 15(6): e0233783 https://doi.org/10.1371/journal.pone.0233783

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