

RESEARCH REPORT

Southern Ontario Participatory Pepper Breeding Project

Farmer-Researchers

Annie Richard & Kathy Rothermel
Kitchen Table Seed House
Frontenac County

Greta Kryger
Greta's Organic Gardens
City of Ottawa

Rebecca Ivanoff
Pocket Seeds
Wellington County

Kim Delaney & Aaron Lyons
Hawthorn Farm Organic Seeds
Wellington County

IN A NUTSHELL

Continuing our work that began in 2016, members of the SeedWorks Plant Breeding Club worked together to breed and release an early, blocky sweet red pepper with good

flavour that is adapted to ecological growing systems in southern Ontario. We continue to select for a yellow sweet bell pepper for release in fall 2021/winter 2022.

MOTIVATION

If you were a farmer 100 years ago you were also a seed saver and, as part of this process, you were also adapting and selecting seed for your preferred agricultural and cultural qualities. Many farming communities have never lost this skill, especially where traditional or peasant agriculture remains. In places like Ontario, where the industrial agricultural system is dominant, farmers like us are reclaiming the knowledge of selection to create varieties that are adapted to changing climatic conditions and the complex environmental stresses that are present in organic and low-input systems. As farmers who have direct contact with those who cook and eat the food, we are producing selections that also have the right characteristics for high quality food (1).

Growing seed, we are acutely aware of the realities of a changing climate, like late killing frosts, hail

storms, increased frequency of heavy rains, periods of extreme heat, and extreme temperature fluctuations. These challenges are further compounded by their influence on the spread, growth, and survival of crop pathogens (2). Breeding for performance under a changing climate is a difficult objective because of its "complexity, its unpredictability, and its location specificity" (3). One strategy is to increase the agrobiodiversity within our fields and farms - as well as within our varieties.

Genetically diverse, locally adapted, and locally celebrated plant populations have been historically maintained by farmers worldwide, though these populations are currently threatened (4). Inspired by the work of Farmer Agricultural Research Committees (known as CIALs) in Honduras, our Haudenosaunee farming neighbours in the region, and the work of Raoul

Robinson, Carol Deppe, and Joseph Lofthouse, the SeedWorks Plant Breeding Club breeds vegetables that are locally adapted to southern Ontario, that are great tasting and have broad genetics, and that can flourish in low-input agricultural systems during a time of climate change.

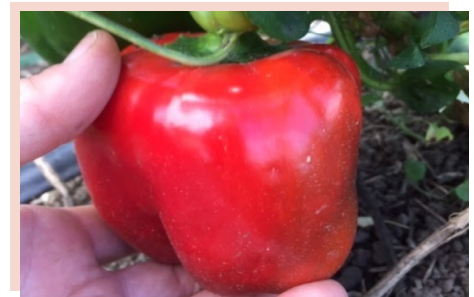


Photo 1. The first pepper to ripen in the mass population grow-out at Kitchen Table Seed House, Aug 18th, 2020.



The five of us began working together after meeting at events organized by the Bauta Family Initiative on Canadian Seed Security. We chose to focus on an early maturing, blocky, sweet bell pepper because all of us had experiences that told us that this was a gap in what was available to organic market growers. The breeding need for this type of pepper also came up in the Northern Organic Vegetable Improvement Collaborative (NOVIC) and the *Canadian Organic and Ecological Plant Breeding Priorities For Vegetable Crops* report by the Bauta Family Initiative on Canadian Seed Security, which found that the key traits for improvement for peppers were productivity/yield (including larger fruits), eating quality, and earliness.

With this focus, our pepper project started in 2016 using seed from a cross made between commercial varieties Ace F1 and Aristotle F1 by Rachel Hultengren, a graduate student in Dr. Michael Mazourek's breeding program at Cornell University. She chose these two hybrids because they represented the earliest ripening (Ace F1) and the most blocky red pepper (Aristotle F1) as identified through the work of NOVIC - a collaboration among Cornell University, University of Wisconsin-Madison, Oregon State University, and the Organic Seed Alliance (5). We grew the first crosses in Ottawa, Wolfe Island, Battersea, and Acton.

In Autumn 2018, we formed the SeedWorks Plant Breeding Club; and this project, along with other breeding work, continues forward under its auspices. The 2020 season was the fifth year we grew the Ace F1 x Aristotle F1 cross at three different locations in the province (this year in Ottawa, Wolfe Island, and Palmerston).

OBJECTIVES

In spring 2020, our objectives for this project were to:

1. Release a genetically diverse but relatively uniform, flavourful, red bell pepper bred for organic field conditions;
2. Release a uniform flavourful red bell pepper suited for organic field conditions;
3. Release a uniform flavourful yellow bell pepper suited for organic field conditions.

DESIGN

Kim Delaney and Greta Kryger are owners of two of the oldest organic seed companies in Ontario. Annie Richard and Kathy Rothermel operate a new successful seed company, with over 30 years of cumulative farming experience. Rebecca Ivanoff farmed organic vegetables for 7 years, is currently the Ontario Coordinator for the Bauta Initiative on Canadian Seed Security, and grows crops at the community gardens at Ignatius Farm. All farms are certified organic.

Objective 1 - Mass Selected Red Pepper

1a) From seed saved from our mass-selected red peppers in 2019, Annie sowed 90 plants on April 4, 2020 and Greta sowed 120 on March 29, 2020. They separated the mass selected population from all other populations/varieties on their farm and neighbouring farms by at least 45 meters. Annie transplanted June 3 and Greta on June 10. Annie and Greta planned to plant Ace F1 and Aristotle F1 as checks but this was not possible (see Findings for more details).

1b) We further compared Renegade Red against other commercial varieties as part of the Canadian Organic Vegetable Improvement (CANOVI) Project - a collaboration between the Centre for Sustainable Food Systems at the University of

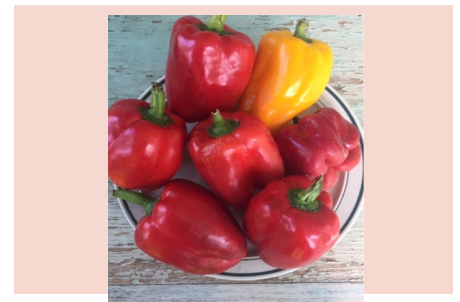


Photo 2. "Varietal" photo of the selected peppers of mass population in 2020. This photo is used on the Kitchen Table Seed House online store. Since the seed will occasionally produce yellow peppers, we chose to include the yellow pepper in the profile photo.

British Columbia and the Bauta Family Initiative on Canadian Seed Security. Specifically, Annie on Wolfe Island, along with two other farms near Kitchener and Thunder Bay, grew Yankee Bell, King Arthur, King Crimson, Ace, King of the North (Fedco strain), Red Knight, and Sprinter. Annie planned to use the Ace plants from these trials as check varieties for the mass selected population at Kitchen Table Seedhouse (see Findings for more details).

Objective 2 - Uniform Red Pepper

In hopes of speeding up the breeding process, Annie planned to grow the red progeny lines out in a heated greenhouse over the winter of 2019-2020. She then planned to plant out the best of the red progeny lines in 2020, cover to allow peppers to self pollinate, observe which of these lines have the most uniformity in plant architecture, early maturity, pepper shape and size, and test which is most flavourful.

Objective 3 - Uniform Yellow Pepper

Kim also planned to work with a local grower with a heated greenhouse to grow our favourite 2019 yellow progeny lines during the winter of 2019-2020, grow them out and continue the selection process in 2020.



FINDINGS

Objective 1 - Mass Selected Red Pepper

1a) As planned for 2020, we saved seed from our favourite blocky, flavourful, red peppers from within this population for 2021 stock seed. We also harvested seed from additional early ripening, blocky flavourful peppers, which could be sold when these seeds were released in winter 2020. At Annie's, there were 4 plants of yellow peppers within this population of 90 plants this season. The first ripe red peppers were observed on August 18, 2020, or 76 days after transplant or days to maturity (DTM). At Greta's, she observed no plants with yellow peppers within her population of 120. Greta observed the first ripe fruit on August 10, or 61 days after transplant (DTM). They selected sweet and crunchy peppers from the best 7 peppers as stock seed. For distribution to the seed houses, Greta also collected seeds from the next 15 best peppers. '

Unfortunately, the mass-selected red pepper population at Kitchen Table Seed House was hit by an early first frost in September. The leaves died and only a handful more peppers managed to ripen after that. Up to this point, Annie had collected a big bin full of fruit that matched the red blocky and early characteristics. She tasted each fruit and saved the seeds from only the really tasty ones, tossing the bland ones to the compost. All in all, Annie was unable to save as many seeds as she had planned; from Kitchen Table Seed House we ended up with only about 100 packets of 25 seeds each from the mass selected red pepper population.

Unlike previous years, due to the global pandemic, we were unable to hold blind taste tests with consumers and friends to confirm more broadly that selections are more flavourful than other red

pepper varieties. However, we tasted each pepper before choosing to save seed from it.

To add insult to injury for the year, the CANOVI trials at Kitchen Table Seed House were destroyed by the severe hail storm on June 7, 2020. This set-back not only reduced the number of sites for this provincial trial to two, but also meant that Annie did not have any checks for comparison. In addition, Greta was not able to order Ace and Aristotle seed, so was also unable to plant check varieties in 2020. Not having checks does not change how the selection process would happen, but it does mean that we could not observe how different our selections were from the parents in this cross.

In the fall of 2020, our early-maturing, blocky red bell pepper with broad genetics was released commercially as 'Renegade Red' pepper. 'Renegade Red' is pledged with the Open Source Seed Initiative (OSSI) and available for the 2021 growing season from Kitchen Table Seed House and Greta's Organic Gardens.

1b) In the CANOVI trials, the mass selection had 84 DTM (4 days longer than Ace) at one farm in Zone 5b, and 92 DTM (same as Ace) in Zone 3a. This was a lot longer than was experienced at Kitchen Table Seed House (76 DTM) and at Greta's Organics (61 DTM).

Objective 2 - Uniform Red Pepper

Due to novel and unexpected shifts in priorities at the beginning of the global pandemic, Annie had to move the red progeny lines that she had planted in the heated greenhouse during the winter of 2019-2020 before they had produced ripe peppers. This meant that in spring 2020, she planted 12 plants from the best two red lines (lines # 2 and #22) from summer 2019 instead of having one season of further selection over the winter.

Unfortunately, the peppers from the red progeny lines were destroyed by the hail storm at Kitchen Table Seed House on June 7, 2020. The leaves on the plants were shredded by the hail leaving only the main stems. Nevertheless Annie left the plants to see if they would bounce back. They did indeed, only to be attacked by caterpillars. It was not a good year to be a pepper on Wolfe Island! Luckily, there were a few fruits that managed to ripen that Annie harvested and saved seed from. Given the difficult year for progress with the red progeny lines, and after conversations with others in the seed community, we decided to discontinue our work with the red progeny lines and focus on the mass selected red pepper population and the yellow pepper lines. Specifically, our mentor Michael Mazourek and colleague Daniel Brisebois are planning to release pure line red peppers that came from the same Ace and Aristotle cross. Further, we feel that the mass selected peppers with broad genetics are more in line with our current desires for varieties with broad genetics (i.e. landraces).

Objective 3 - Uniform Yellow Pepper

Due to unprecedented demand for seed at the beginning of the pandemic in early 2020, Kim was also unable to secure a spot to grow the yellow progeny lines in a heated greenhouse. During the summer of 2020, Kim planted lines G1, K1, K2 of the yellow progeny lines, while Greta planted lines G1 and G2 with 12 plants each under row cover so that they self-pollinated. Kim had space for about 65 of each of these lines, all of which she kept under row cover.

We saved seeds from all lines but concluded yellow progeny line G1 performed the best at both locations. We also identified the best plants in lines that were most uniform and flavourful to grow out in 2021.



Table 1. Planting details and date to first ripe fruit for the SeedWorks pepper lines.

	Red Progeny Lines at Kitchen Table Seed House (Lines # 2 and #22)	Red Mass Population at Kitchen Table Seed House	Red Mass Population at Greta's Organics	Yellow Progeny Lines at Greta's Organics (Lines G1 and G2)	Yellow Progeny Lines at Hawthorn Farm Organic Seeds (Lines G1, K1, K2)
Date seeded	April 4	April 4	March 29	March 29	April 2
Date transplanted into the field	June 2	June 3	June 10	June 10	June 12
Number of plants transplanted	8 of each	90	120	12 of each	200 (three lines G1, K1, K2)
Date of first ripe fruits (Days to Maturity)	n/a	August 18 (76 DTM)	August 10 (61 DTM)	August 10 (61 DTM)	September 3 (83 DTM)

TAKE HOME MESSAGE

We achieved a significant milestone with the commercial release of 'Renegade Red,' an open pollinated, early-maturing, blocky red bell pepper. To do this, we selected the Open Source Seed Initiative (OSSI) model for 'Renegade Red,' as the OSSI pledge "preserves the rights of farmers, gardeners, and breeders to freely use, save, replant, and improve seed" of this variety while preserving SeedWorks' ability to maintain its quality and identity.

NEXT STEPS

During the 2021 season, we are growing Renegade Red for seed at Kitchen Table Seed House and Greta's Organics, and continue to select the peppers that mature the earliest and taste the best. We also continue to feel strongly that heterogeneous food crops with broad genetics are needed as we face climate change, and are excited to be able to talk about this when describing our newly released Renegade Red pepper population!

In addition to Renegade Red, we continue to select uniform progeny lines of blocky yellow peppers. We are growing out the G1 line (variety name to be decided) at Hawthorn Farm Organic Seeds, Kitchen Table Seed House, and Greta's Organics during the 2021 season. During this season, Pocket Seeds is doing a variety trial of the G1 line compared to other field bell peppers (Admiral F1, Brocanto F1, Elsa F1, Golden California Wonder, Sweet Sunrise F1) recommended by farmers and organic seed companies. We plan to release a yellow progeny line in late fall 2021 and plan to also protect this line through an OSSI pledge.

We continue to work together to breed other vegetable crops on our farms in partnership with the plants themselves and our generous seed community.



Photo 3. SeedWorks Plant Breeding Club members Rebecca Ivanoff, Greta Kryger, Annie Richard and Kathy Rothermel (missing Kim Delaney) in 2017.



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Photo 4. Pepper plants covered at Kim Delaney's farm in 2019.



Photo 5. Example of Renegade Red compared to parent varieties Aristotle and Ace ca. 2019.

ACKNOWLEDGEMENTS

We'd like to thank the peppers for participating in this co-evolutionary dance with us, and to all those who have saved seeds from these peppers over the last 6,500 years as they have travelled from hand to hand around the globe. We'd like to thank our colleague Michael Mazourek for teaching us some of the dance steps to this process, and to Rachel Hultengren for doing the initial cross at the start of this project. We'd also like to thank the Bauta Initiative on Canadian Seed Security for creating opportunities for learning together which led to the formation of SeedWorks Plant Breeding Club, and the Ecological Farmers Association of Ontario for supporting us in creating protocols and financially through researcher stipends.

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