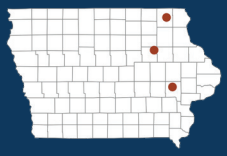
PRACTICAL FARMERS OF IOWA
COOPERATORS' PROGRAM Farmer-Led Research

EXPERIMENT



2024

Sweet Pepper Variety Trial

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In a Nutshell:

- The 'Carmen' F1 variety sweet pepper is an excellent pepper, but the complexities of maintaining an F1 hybrid line are reflected in the seed price.
- Cooperators were motivated to identify an OP line that could match or come close to Carmen, whose quality would be stable intergenerationally.

Key Findings:

- Carmen produced the highest total yields and largest peppers.
- In taste tests, Carmen peppers were almost always sweeter than the other varieties.
- At Pipho's farm, Corno di Torro produced more individual peppers, over a longer period than Carmen.

Cooperators

Hannah Breckbill & Emily Fagan, Humble Hands Harvest – Decorah, IA

Marla Looper, Bountiful Harvest Farm – North Liberty, IA

Michael Pipho, Rooster's Crow Farm – Dunkerton, IA

Funding

IDALS

Ceres Trust

The Builders Initiative

BACKGROUND

'Carmen' is a best-selling and best-producing F1 sweet pepper variety. "F1" designates it as a hybrid, the product of the controlled crossing of two distinct parental lines. As such it benefits from heterosis (hybrid vigor) where the offspring of hybrid crossings outperform the parental lines because they inherit the benefits from both parents. Carmen tastes good, matures rapidly, and is well adapted to cooler growing environments like Iowa. However, its hybrid background comes with a downside: it requires the management of the two distinct lines, with controlled, hand-pollinated, crosses to produce Carmen hybrid offspring. This adds cost and complexity for the seed producers, which is passed to the grower as additional cost.

Carmen plants produce well, but saving and regrowing Carmen seeds is not practical, as the future generations will be less consistent, with more of the parent-line traits fully expressed, including possible deleterious traits.

An alternative is to grow non-controlled, open pollinated (OP) varieties. Rather than coming from a single controlled lineage, or the crossing of two lineages, OP plant varieties are population of plants that have been selected for desired characteristics, with no control of pollination. OP lines are not as consistent between individuals in the line as F1 hybrid lines, but are more consistent over time across generations. The larger pool of genes in an OP line—which results in this lower inter-individual level of similarity—makes the line more resilient against climate change, and against weather or other shocks for which a hybrid might not have been selected.

Peppers growing at Michael Pipho's farm. Photo taken summer 2024.

Hannah Breckbill and Emily Fagan, Marla Looper, and Michael Pipho were motivated to carry out this investigation of Carmen and OP pepper varieties to inform their efforts to save good seeds and genetic material for future use, to increase their operations' resiliencies. Seed saving also helps secure financial and logistic independence from the seed company. Fagan wrote "If we can find an open pollinated pepper variety that we like just as well as Carmen, then we'd be able to save the seed if we wanted to. It could help us feel more resilient, being able to work on a Midwest-adapted variety."

TABLE 1. Sweet Pepper varieties grown by cooperators in 2024 and their relevant attributes.

VARIETY	HYBRID or OP	DAYS TO MATURITY (green/red)	SEED COMPANY	RELEVANT TRAITS
Carmen	Hybrid	60g/80r	Johnny's	Cold resistant, high yield, AAS
Italia	OP	55g /70-80r	Seed Savers Exchange	Sweet, thin walls, organic
Corno di Toro	OP	70g/78r	High Mowing	Sweet, full-bodied flavor, vigorous, organic
Bridge to Paris	OP	83r	Territorial	High yield, 'dehybridized', tall plant

METHODS

Design

Cooperators tested the following sweet pepper varieties: Carmen, Italia, Corno di Torr, and Bridge to Paris. Carmen served as a standard point of comparison and was grown by all of the farms. The other varieties tested against Carmen were selected by the cooperators based on their individual preferences and seed availability (**Table 1**). Production practices for each farm are presented in **Table 2**. Seeds were started indoors and transplanted outside in mid-May. Each cooperator established at least four replicates of each selected variety.

TABLE 2. Planting and management practices for each cooperator's trial in 2024.

	PIPHO	LOOPER	BRECKBILL & FAGAN
Varieties trialed	Carmen, Italia, Corno di Toro	Carmen, Italia	Carmen, Bridge to Paris
Plants per plot	6	4	22
Row width	24 in .	36 in.	20 in.
In-row spacing	18 in.	18 in.	12 in.
Seeding date	Apr. 1	Mar. 24	Mar. 11
Transplanting date	May 15	May 23	May 28
Fertilization/mulch	15 g bone meal & 15 g organic fertilizer in each transplant hole	Landscape fabric	None
Irrigation	Drip irrigation: 3 gal/plant/week	Sprinkler, rain, drip tape	Mixed

Measurements

Harvesting about once a week during the harvest window, from August 8 through October 4, 2024, cooperators weighed the marketable peppers, and counted the number of marketable fruits, enabling the calculation of an average weight for each replicate.

They also tasted a random sampling of the marketable peppers from each variety. They noted whether the OP varieties were more, less, or as sweet as Carmen.

Data analysis

We used Fischer's LSD at a 95% confidence level to determine if there were significant differences between varieties. For each metric, the difference between any two varieties is compared with the LSD. A difference greater than or equal to the LSD indicates the presence of a statistically significant treatment effect, meaning one variety outperformed the other and the farmer can expect the same results to occur 95 out of 100 times under the same conditions. A difference smaller than the LSD indicates the difference is not statistically significant and the treatment had no effect. We can perform this analysis where the cooperators had completely randomized and replicated experimental designs (**Figure A1**).

RESULTS AND DISCUSSION

Pipho

Pipho saw good germination from all three of his varieties (>95%) and had 100% survival after transplantation. Corno di Toro and Italia were less productive and had more variation between plants and peppers than Carmen (**Table 3**). Corno di Toro produced more total individual peppers than Carmen, the only metric in the entire project where Carmen was surpassed.

He noted that Carmen started slightly faster than the other two (Italia, Corno di Toro) and were slightly larger at transplantation (**Figure 1**). Perhaps due to his later seeding and transplanting dates, his production peaked later than Looper's. Pipho had some standout Corno di Toro individuals producing for weeks after the other plants had stopped. He remarked that Corno di Toro's longer, shallower production arc worked well for him, since at the peak of the season he had more peppers than he could use and he was forced to find alternative outlets.

Looper

Looper saw higher yields from Carmen than Italia throughout the harvest season (**Figure 2**).

Because her peppers were bulk harvested, the results could not be analyzed statistically, but there were large differences between the varieties. Her average weight of the Carmen peppers matched Pipho's average Carmen weight; her Italia peppers were larger, on average than Pipho's. Ultimately, Carmen produced 48% more total harvest, mostly attributable to the fact that Carmen produced 33% more fruits than Italia (**Table 4**).

Looper recorded taste-test results for every week of harvest. At the peak of the production (Aug. 27), Looper judged Italia to be as sweet as the Carmen sample that week. All other weeks, the Italia sample was less sweet than the Carmen.

TABLE 3. Pepper yields at Pipho's farm in 2024.

VARIETY	TOTAL PEPPER HARVEST (lb/plot)	TOTAL PEPPER COUNT (no./plot)	AVG PEPPER WEIGHT (lb/pepper)	COST OF 50 SEEDS
Carmen	34.7 a	158 b	0.22 a	$10.95
Italia	12.5 c	73 c	0.17 b	$7.90
Corno di Torro	29.4 b	174 a	0.17 b	$11.99
LSD (95%)	2.8	13	0.03	--

Within a column, when the difference between the two averages is greater than or equal to the corresponding least significant difference (LSD), the yields are considered statistically different at the 95% confidence interval. When the difference is less than the LSD, there is no significant statistical difference. Groups with the same letter are not significantly different from each other.

TABLE 4. Pepper yields at Looper's farm, summer 2024.

VARIETY	TOTAL PEPPER HARVEST (lb)	TOTAL PEPPER COUNT (no.)	AVG PEPPER WEIGHT (lb/pepper)	COST OF 25 SEEDS
Carmen	52.7	239	0.22	$5.30
Italia	35.5	180	0.20	$4.30

Looper's results could not be analyzed statistically. The results were not reported by replicate, instead as block harvests each week for each variety. The data reported in this table summarizes the whole harvest period, but conclusions about the significance of differences between results cannot be drawn.

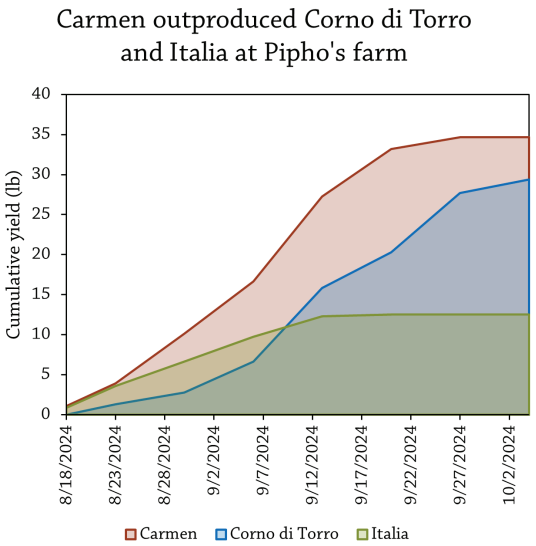


FIGURE 1. Pipho's cumulative pepper yield through the harvest period in 2024. Italia underperformed Carmen and finished early. Carmen production peaked in early-mid September. Corno di Torro started slower and never reached the same weekly peak yields as Carmen, but lasted longer, still producing into October.

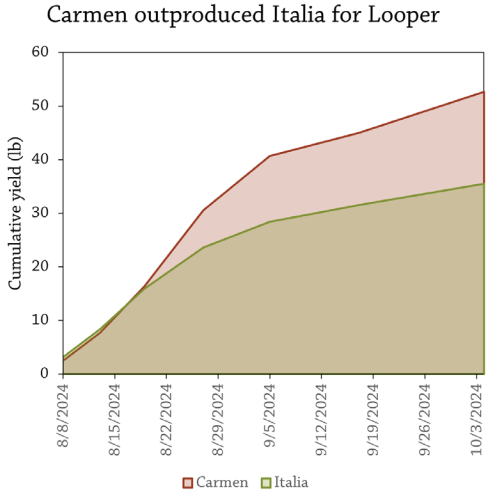


FIGURE 2. Looper's cumulative pepper yield through the harvest period. Both varieties reached peak production in late August, with Carmen outstripping Italia.

Breckbill & Fagan

Breckbill & Fagan found that Carmen produced larger, sweeter peppers than Bridge to Paris, but they had challenges in their trial that limited their results and the conclusions they could draw. They had to repeat the germination of Bridge to Paris on Apr. 23, 2024 because of poor gemination in the first cohort. Their harvest was unfortunately ruined by sheep that got into the pepper field. Comparing yields between varieties was not possible, but the average pepper size was calculated from the surviving individuals (**Table 5**). They made taste comparisons between Carmen and Bridge to Paris, and found Carmen were consistently sweeter than the Bridge to Paris peppers.

TABLE 5. Pepper results from Breckbill & Fagan, summer 2024.

VARIETY	AVG PEPPER WEIGHT (lb/ pepper)	TASTE COMPARISON
Carmen	0.29	More sweet
Bridge to Paris	0.15	Less sweet

CONCLUSIONS AND NEXT STEPS

This project was conducted in hopes identifying an open-pollenated, 'bull's horn', Italian sweet pepper variety that could rival the Carmen F1 hybrid by Johnny's Seeds, which Breckbill & Fagan referred to as their 'gold standard' variety. We evaluated three alternative varieties, and although none matched Carmen in total yield or pepper size, individual varieties' traits could find niches in a diversifying operation. For example, Corno di Toro produced more individual peppers, over a longer period at Pipho's farm, which he wrote would help him to extend his season.

The trials helped cooperators evaluate whether any of the alternative varieties would meet their needs. Breckbill & Fagan wrote that they would avoid Bridge to Paris for market production. Pipho wrote that he "saw a very clear difference between the pepper varieties tested, which will help [him] make better planting decisions going forward. He will be planting approximately equal numbers of the Carmen and Corno di Torro peppers… Based on the results, [he] will not be planting Italia plants."

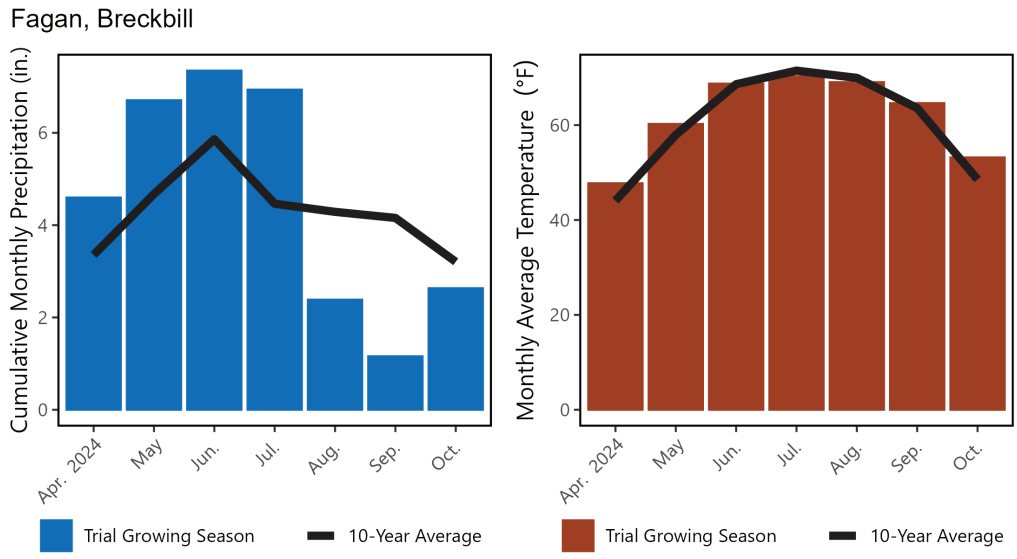
This project will be repeated in 2025.

APPENDIX — TRIAL DESIGN AND WEATHER CONDITIONS

REP 1	**Italia**	**Carmen**	**Corno di Toro**
REP 2	**Corno di Toro**	**Italia**	**Carmen**
REP 3	**Carmen**	**Corno di Toro**	**Italia**
REP 4	**Italia**	**Corno di Toro**	**Carmen**

REP 1	**Italia**	**Carmen**
REP 2	**Carmen**	**Italia**
REP 3	**Carmen**	**Italia**
REP 4	**Italia**	**Carmen**

FIGURE A1. Experimental designs used by Pipho, Looper, and Breckbill & Fagan.



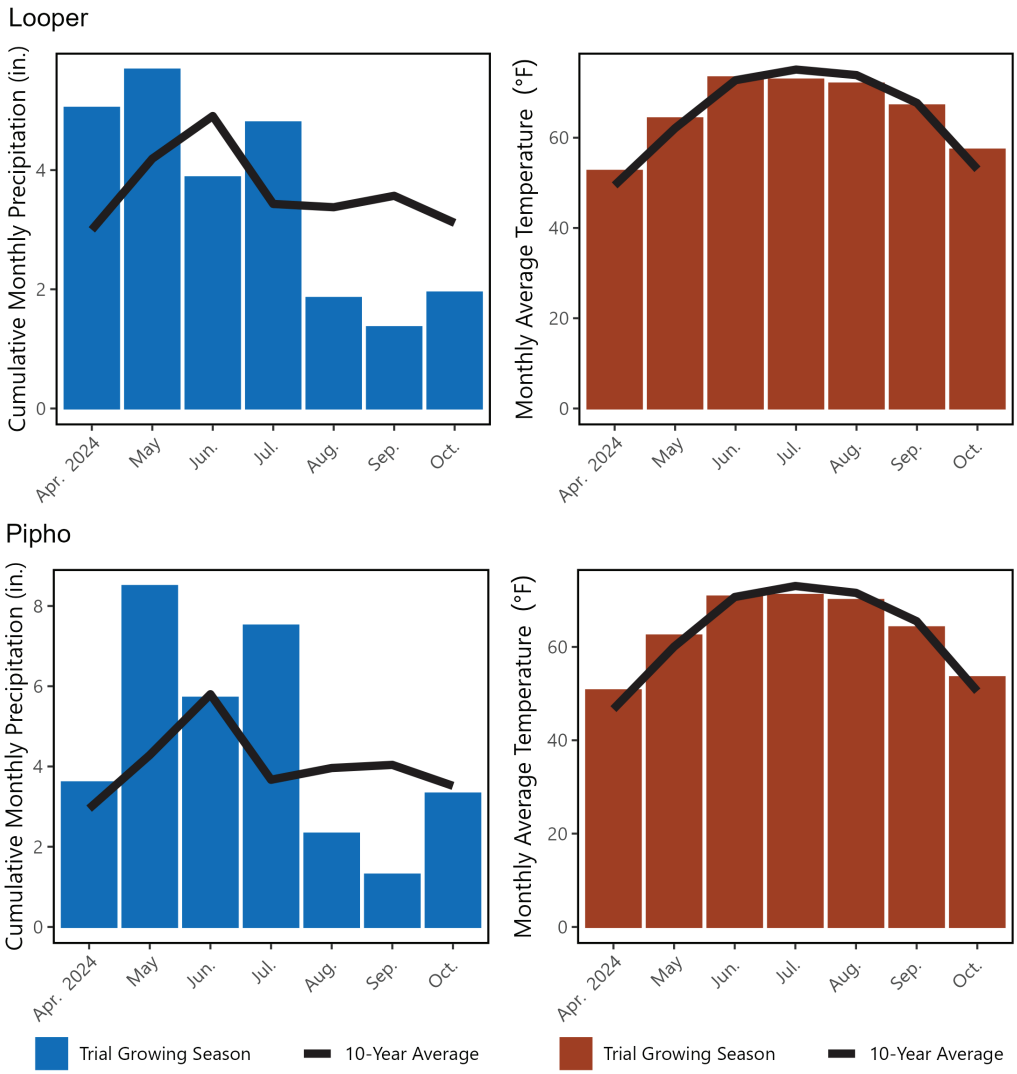


FIGURE A2. Monthly cumulative precipitation and average temperatures in Decorah, North Liberty, and Dunkerton over the course of the experiment, April – October, 2024 [1], [2].

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PRACTICAL FARMERS of Iowa

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