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# Colored Sweet Bell and Tapered Pepper Cultivar Evaluation for High Tunnel Production in West-Central Indiana, 2023

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Colored sweet bell-shaped and tapered pepper is a summer crop that is grown by many small and medium-sized farming operations in Indiana. Growers can choose to grow peppers out in the field or plant them under a protective structure. Sweet peppers, in particular, benefit from the unique growing environment created by a high tunnel. Planting of peppers can start at least 2-4 weeks earlier in the spring, and production can continue into the fall until the first hard freeze. Pepper variety performance data for Indiana is not readily available. We are working hard to change that. To date, we have evaluated thirty pepper varieties, and each variety is assessed in two production cycles. This paper reports on five sweet bell and five tapered pepper entries (Table 1; Figures 9 – 18) evaluated at the Purdue Student Farm, West Lafayette, Indiana.

## Materials and Methods

The trial was conducted on a Mahalassville (Md) silty clay loam. The fall soil test showed 8.7% organic matter, pH 7.2, and 162 ppm phosphorus (P), 160 ppm potassium (K), 778 ppm magnesium (Mg), and 3949 ppm calcium (Ca). The cation exchange capacity was 27.1 meq/100 gram. Nitrogen, 140 lb/A N from Urea (46-0-0), and potassium, 155 lb/A from sulfate of potash (0-0-50) (Ohio Earth Food), was applied pre-plant. No phosphorus was applied pre-plant due to the very high soil phosphorus content. Nature's Source<sup>®</sup> 10-4-3 was applied by fertigating 15 lb/A N at six and eight weeks after transplanting. Full season nitrogen application totaled 170 lb.A.

The trial was set up in a 30-foot (W) by 96-foot (L) high tunnel (Nifty Hoops, MI) as a randomized complete block design with six replications (Fig. 3-4). The high tunnel had louvered gable vents (one at each end wall) and roll-up sidewalls. The louvered aluminum vents open automatically at approximately 65-75 °F with a temperature-controlled wax cylinder, and the side walls were opened when inside temperatures reached 75 °F and closed when temperatures dropped below 60 °F. Sweet pepper entries were assigned to individual plots containing one row of five plants that were 7.5 feet long. Peppers were seeded on April 10, 2023, and transplanted on May 12, 2023, with an in-row spacing of 1.5 feet and between-row spacing of 4 feet (7,260 plants per acre). The walkways between the rows (4 feet center-to-center) were covered with a black woven polypropylene ground cover (DeWitt Sunbelt<sup>™</sup>). Additionally, a 3 feet wide white woven polypropylene ground cover was placed on top of the black ground cover to increase light in the lower plant canopy. Irrigation was applied daily using drip tape (Rivulis T-tape 5/8") with a 12" emitter spacing and flow rate of 0.22 GPM/100 feet. Two drip tape lines were used per row, with the emitters positioned diagonally from one another. This ensures even soil moisture distribution along the planting row. Irrigation volume was increased according to plant growth, soil, and climatic conditions.

Peppers were trellised using the HD trellis support (8 inches wide, 37 inches high plus 13-inch-long legs at the base, Nolts Produce Supplies LLC, PA) and trellis twine (Fig. 3 and 4). No pruning was done during the growing season. Weed control was minimal and done by hand. Yellow and blue sticky cards were used for insect monitoring and to attract and capture the adult life stage of insect pests. Pest pressure was very low; therefore, no foliar pesticide applications were made during the growing season. We did experience some rabbit feeding pressure, especially on the maturing fruit.

Each plot was harvested after the peppers reached their mature color. Harvesting continued once a week between 91 and 166 days after transplanting. For each plot, the marketable and unmarketable number of fruit and fruit weight were recorded weekly, and fruit size (length and width) was recorded with an electronic digital caliper (VINCA DCLA-0605) at the second harvest (98 days after transplanting). Fruit size data was collected from ten fruits of each variety. Fruit width was measured on the widest part of the shoulder, and fruit length was calculated from the top of the shoulder to the bottom of the fruit. Fruits were classified in the following length-to-diameter ratios:  $\leq 0.95$ : very blocky, flattened shape; 1.00: blocky, length equal to diameter;  $\geq 1.05$ : an elongated shape with length greater than the diameter. During the last harvest, October 25, 2023, all mature colored and mature green fruit were harvested and recorded. The marketable yield was expressed as yield per plant or yield per acre. Data were analyzed using ANOVA followed by treatment means separation using Tukey-Kramer's least significant difference at  $P \leq 0.05$ .

## Results

### Marketable Yield

Marketable fruit yield and weight results are presented in Table 2. Data show significant statistical differences for marketable fruit count per plant, the number of marketable fruits per acre, fruit weight, and yield differences among entries. During this evaluation, Cornito Giallo (42.5), Peppigrande (41.9), Cornito Arancia (38.9), and Carmen (36.4) produced the most fruits per plant and acre, significantly higher than the other tapered or bell-shaped pepper entries. The fruit yield per plant of bell pepper entries Flavorburst (19.4) and Sweet Sunrise (22.9) was 19% and 31%, respectively, higher than in 2022 (Langenhoven et al., 2022). Overall, bell pepper yields increased from 2022, except for var. Regulator that decreased by 5%.

This season, four new tapered pepper variety entries were included in the evaluation. Fruit yields ranged between 42.5 (Cornito Giallo) and 26.2 (Mama Mia Giallo) per plant. The standard varieties Flavorburst (19.4) and Carmen (36.4) produced within their long-term range of 15-20 and 30-35 fruits per plant, respectively. Bell pepper varieties Sweet Sunrise (22.9) and Flavorburst (19.4) produced significantly more fruit than Var. Regulator (12.6).

The tapered pepper variety Peppigrande produced the highest fruit yield (10.1 lb) per plant, significantly higher than bell pepper entry Regulator (7.5 lb) and tapered pepper entry Cornito Arancia (6.4 lb). There is no significant difference in the production of bell pepper variety entries and tapered pepper varieties Carmen (9.4), Mama Mia Giallo (8.1 lb), and Cornito Giallo (7.8 lb). Cornito Arancia produced the lowest fruit yield per plant.

Again, fruit from bell pepper entries was significantly heavier. Turnpike (11.1 oz) and PS 09941819 (10.5 oz) produced the largest fruits. Sweet Sunrise fruit weight (6.3 oz) was the

lowest of all the bell pepper entries, but it was consistent with results obtained in 2022. Fruit from tapered pepper varieties was significantly lighter. Cornito Arancia (2.6 oz) and Cornito Giallo (2.9 oz) produced the lowest average fruit weight. Mama Mia Giallo produced the largest tapered pepper fruit.

### Fruit Characteristics

Bell and tapered pepper fruit characteristics (length, width, and shape) were recorded (Table 3). The tapered pepper variety entry Mama Mia Giallo (7.8 inches) was significantly longer. Cornito Arancia produced the smallest tapered pepper (5.8 inches). As expected, the tapered varieties had significantly longer fruit than the bell pepper variety entries.

Bell pepper fruit length ranged from 3.9 inches (Regulator and Sweet Sunrise) to 4.6 inches (Flavorburst). Bell pepper fruit lengths did not differ significantly from each other but were significantly shorter than the tapered pepper varieties. As expected, bell peppers were significantly wider at the shoulder, the rounded part of the pericarp just below the calyx, than tapered peppers. Bell pepper fruit width varies between 3.4 and 4.0 inches in contrast to tapered peppers, which are between 1.9 and 2.3 inches. None of the bell pepper varieties were classified as blocky. All tapered and bell pepper entries were classified as elongated (ratio  $\geq 1.05$ ).

### Unmarketable Yield

Tapered pepper varieties produce more unmarketable fruit per plant, significantly more than bell pepper varieties Regulator (1.9) and Flavorburst (1.2) (Table 4). The highest number of unmarketable fruits per plant was harvested from var. Peppigrande (15.7). Fruit culls result from blossom end rot (BER), cork-like striations (scarring that appears on the surface skin of a pepper) on the shoulder, the sides, or the blossom end of the fruit, fruit that is soft (turgor loss), fruit damaged by rabbits or insect feeding, or fruit that is small. The high number of culls from Peppigrande and Cornito Giallo is mostly made up of small fruits. Mama Mia Giallo produced fruit that showed signs of turgor loss, especially later in the growing season.

Bell pepper cull numbers were very low, between 0 and 0.6, and did not differ significantly. In general, a high percentage of the total culls was the result of BER (Figure 1). Tapered pepper entries Carmen (33.4%) and Mama Mia Giallo (16.0%), and bell pepper entries Regulator (30.0%) and PS 09941819 (16.6%) had a significantly higher percentage of their unmarketable culls as BER culls. Bell pepper variety Flavorburst (1.9%) and tapered pepper variety Cornito Arancia had no BER fruit.

The unmarketable yield per plant of Mama Mia Giallo (2.1 lb), Peppigrande (2.0 lb), Turnpike (2.0 lb), Carmen (1.5 lb), and PS 09941819 (1.5 lb) was significantly higher than most other varieties. Turnpike had some BER (0.2 fruit per plant), but most culls were affected by cork-like striations on the fruit's shoulder, side, and blossom end (Figure 7). Mama Mia Giallo produced several BER-affected fruits (1.5 per plant) and was the only variety that produced fruit at harvest that showed signs of a loss in turgor. Regulator produced a few fruits with an epicarp that was split open. Flavorburst produced the lowest unmarketable yield (3,052 lb./A).

The highest percent culls (number of unmarketable fruits as a fraction of the total number of fruits harvested from a plant) was observed with tapered varieties Peppigrande (27.3%) and Mama Mia Giallo (25.8%) and bell varieties Turnpike (20.8% and PS 09941819 (18.8%) (Figure 2). The lowest percent cull was observed with Flavorburst (5.6%).

## Discussion

All entries, except Mama Mia Giallo, performed well. Compared to 2022, Sweet Sunrise, Flavorburst, and Turnpike yields increased by 2.0, 1.6, and 1.5 lb per plant, respectively (Langenhoven et al., 2022). This is mainly due to a 30.5% (Sweet Sunrise), 22.6% (Turnpike), and 18.7% (Flavorburst) increase in the number of marketable fruits harvested per plant. This might be the result of more moderate summer temperatures, which resulted in less flower or fruit abortion. Bell pepper variety yields were between 54,000 and 67,000 lb./A. Although Regulator produced the lowest yield, it consistently produced fruits with four lobes that are almost blocky. Sweet Sunrise (yellow bell pepper) is a great alternative to Flavorburst (also yellow bell pepper). The bell pepper Turnpike produces jumbo-sized fruits (11.1 oz) and high yields (67,407 lb/A), but it tends to produce fruit with cork-like striations. My top bell pepper picks will be Flavorburst, Sweet Sunrise, and Regulator.

Just like Oranos, an orange tapered pepper (Langenhoven et al., 2022), Cornito Arancia is a very sweet, bright orange pepper with exceptional flavor and is a prolific producer (282,415 fruit/A). However, the fruits of Cornito Arancia are slightly larger, and this variety is not at all affected by BER. Similarly, Cornito Giallo is a prolific producer (308,551 fruit/A) of yellow, firm, and sweet fruit. Peppigrande was a surprise (73,404 lb/A), outperforming Carmen (68,445 lb/A), the tapered pepper industry standard in this variety trial. This tapered pepper variety often produces fruit with no seeds. Peppigrande also started to produce harvestable fruits later (at 104 days after transplanting) than other tapered pepper varieties and continued to produce many fruits to the very end of the growing season. Mama Mia Giallo produced the largest fruits of all tapered pepper entries. However, there is a concern that a high number of fruits at harvest tends to have lost turgor. Fruits were picked at 80-90% full color. Next season, we will evaluate if this variety needs to be picked earlier to maintain turgor.

It would be interesting to see how these tapered pepper varieties perform in 2024. In addition to Flavorburst, we will include four new bell pepper varieties in the 2024 trial.

## Acknowledgments

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## References

Langenhoven, P., L. Duron and E. Miranda. 2022. Colored Sweet Bell and Tapered Pepper Cultivar Evaluation for High Tunnel Production in West-Central Indiana, 2022. Midwest Variety Trial Report. Accessed on December 18, 2023. <https://docs.lib.purdue.edu/mwvtr/243/>

**Table 1.** Colored sweet bell and tapered pepper cultivar characteristics\*.

<b>Cultivar</b>	<b>Type</b>	<b>Days to Maturity <sup>z</sup></b>	<b>Immature Fruit Color</b>	<b>Mature Fruit Color</b>
PS 09941819 (with X5R <sup>®</sup> )	Bell Pepper	86	green	red
Regulator	Bell Pepper	86	green	red
Turnpike (with X5R <sup>®</sup> )	Bell Pepper	87	green	red
Flavorburst	Bell Pepper	87	lime green	golden yellow
Sweet Sunrise	Bell Pepper	85	green	yellow
Cornito Giallo	Tapered Pepper	75	green	yellow
Carmen	Tapered Pepper	80	green	red
Mama Mia Giallo	Tapered Pepper	85	green	yellow
Cornito Arancia	Tapered Pepper	80	green	orange
Peppigrande	Tapered Pepper	85	green	red

\*Data obtained from seed company listed information

<sup>z</sup> Days to maturity from transplanting to mature fruit color

**Table 2.** Marketable yield of colored sweet bell and tapered pepper cultivars.

<b>Cultivar</b>	<b>Number of fruits per plant<sup>z</sup></b>	<b>Number of fruits per Acre<sup>z</sup></b>	<b>Fruit Weight (oz)<sup>z</sup></b>	<b>Yield (lb/plant)<sup>z</sup></b>	<b>Yield (lb/Acre)<sup>z</sup></b>
PS 09941819 (with X5R®)	13.4 de	97,163 de	10.5 a	8.8 ab	63,990 ab
Regulator	12.6 e	91,234 e	9.6 b	7.5 bc	54,256 bc
Turnpike (with X5R®)	13.4 de	97,526 de	11.1 a	9.3 ab	67,407 ab
Flavorburst	19.4 cd	140,844 cd	7.3 c	8.8 ab	64,003 ab
Sweet Sunrise	22.9 bc	166,012 bc	6.3 d	9.0 ab	65,090 ab
Cornito Giallo	42.5 a	308,551 a	2.9 g	7.8 bc	56,921 bc
Carmen	36.4 a	264,083 a	4.2 f	9.4 ab	68,445 ab
Mama Mia Giallo	26.2 b	189,970 b	5.0 e	8.1 abc	59,142 abc
Cornito Arancia	38.9 a	282,415 a	2.6 g	6.4 c	46,182 c
Peppigrande	41.9 a	304,255 a	3.9 f	10.1 a	73,404 a
<i>Pr &gt; F</i>	<.0001	<.0001	<.0001	<0.0001	<0.0001

<sup>z</sup>Means followed by the same letter are NOT significantly different at  $P = 0.05$ , Tukey-Kramer.

**Table 3.** Colored sweet bell and tapered pepper fruit characteristics.

<b>Cultivar</b>	<b>Fruit Length (inch)<sup>z</sup></b>	<b>Fruit Width (inch)<sup>z</sup></b>	<b>Fruit Shape<sup>y</sup></b>	<b>Fruit Shape Classification<sup>y</sup></b>
PS 09941819 (with X5R <sup>®</sup> )	4.2 d	4.0 a	1.05 d	elongated
Regulator	3.9 d	3.6 bc	1.11 d	elongated
Turnpike (with X5R <sup>®</sup> )	4.5 d	3.8 ab	1.18 d	elongated
Flavorburst	4.6 d	3.5 c	1.31 d	elongated
Sweet Sunrise	3.9 d	3.4 c	1.14 d	elongated
Cornito Giallo	6.6 b	1.9 f	3.51 ab	elongated
Carmen	6.9 b	2.3 de	3.10 bc	elongated
Mama Mia Giallo	7.8 a	2.3 d	3.35 abc	elongated
Cornito Arancia	5.8 c	2.0 ef	2.90 c	elongated
Peppigrande	6.7 b	1.9 f	3.66 a	elongated
<i>Pr &gt; F</i>	<.0001	<.0001	<.0001	

<sup>z</sup> Means followed by the same letter are NOT significantly different at  $P = 0.05$ , Tukey-Kramer.

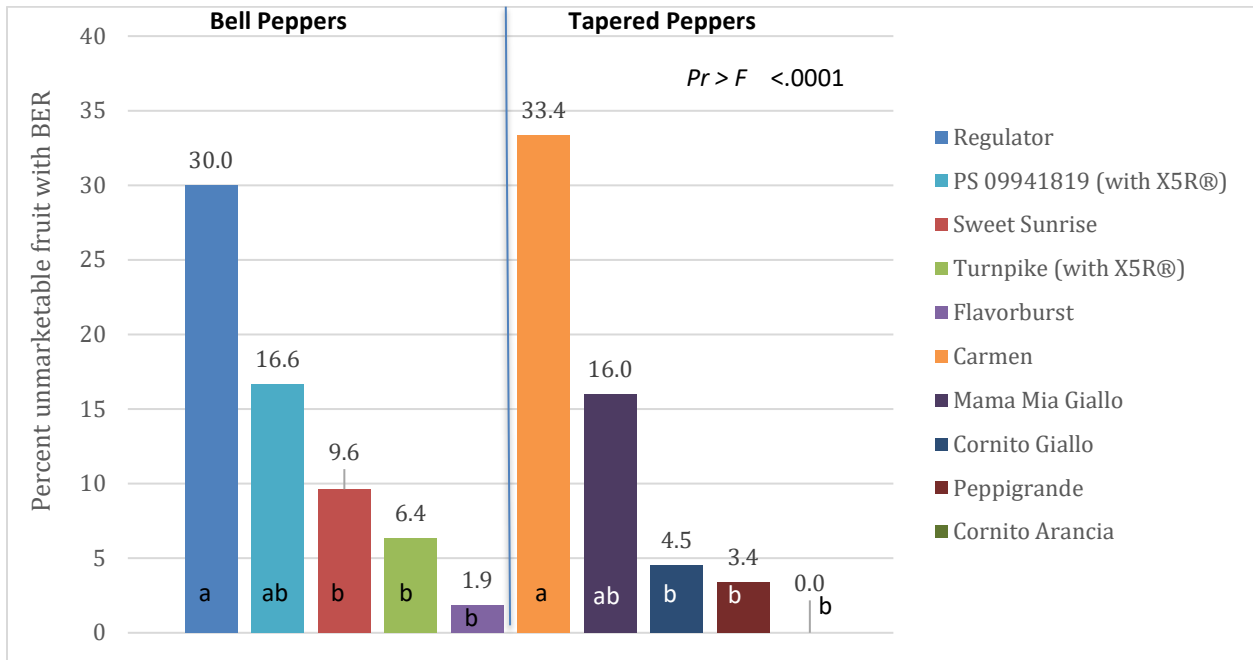
<sup>y</sup> Length to diameter ratio;  $\leq 0.95$ : very blocky, flattened shape; 1.00: blocky, length equal to diameter;  $\geq 1.05$ : an elongated shape with length greater than the diameter.



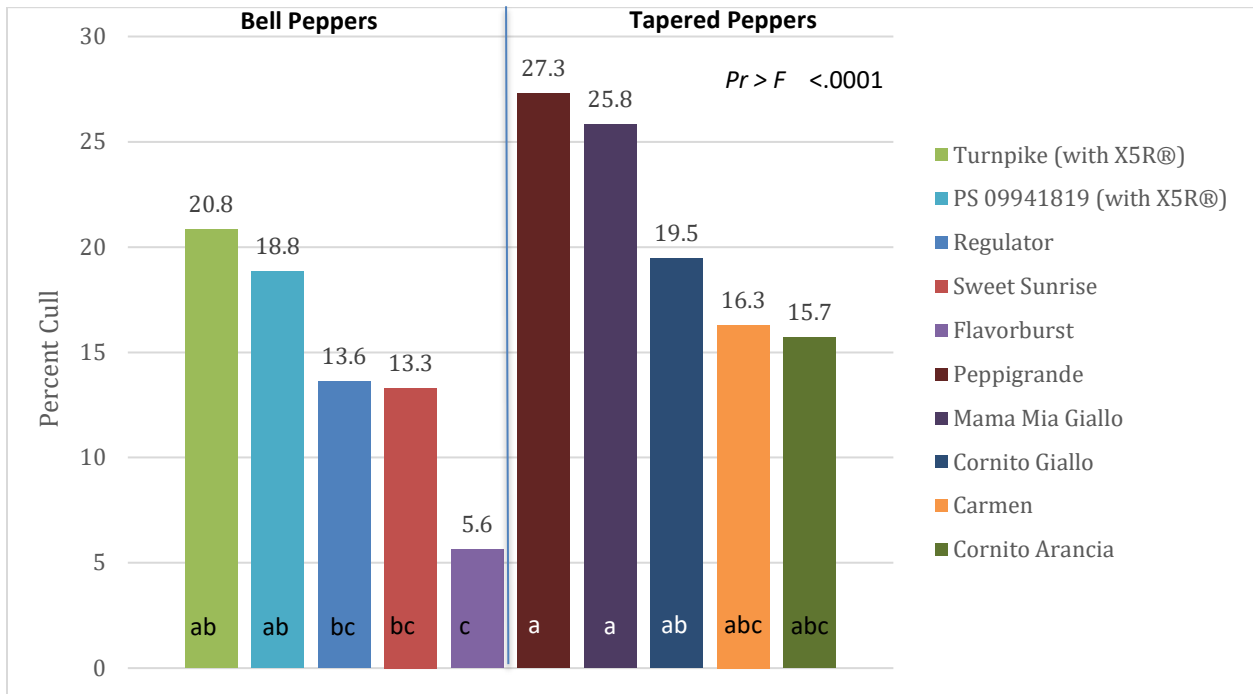
**Table 4.** Unmarketable yield of colored sweet bell and tapered pepper cultivars.

<b>Cultivar</b>	<b>Total number of unmarketable fruits per plant<sup>z</sup></b>	<b>Number of BER fruits per plant<sup>z</sup></b>	<b>Unmarketable yield (lb/plant)<sup>z</sup></b>	<b>Unmarketable yield (lb/Acre)<sup>z</sup></b>
PS 09941819 (with X5R®)	3.1 cd	0.6 bc	1.5 ab	11,047 ab
Regulator	1.9 d	0.5 bc	0.9 bc	6,529 bc
Turnpike (with X5R®)	3.5 cd	0.2 bc	2.0 a	14,596 a
Flavorburst	1.2 d	0.0 c	0.4 c	3,052 c
Sweet Sunrise	3.6 cd	0.4 bc	1.0 bc	7,012 bc
Cornito Giallo	10.2 bc	0.5 bc	1.4 b	10,291 b
Carmen	7.2 bc	2.6 a	1.5 ab	10,763 ab
Mama Mia Giallo	9.3 bc	1.5 ab	2.1 a	15,040 a
Cornito Arancia	7.2 bc	0.0 c	0.8 bc	6,102 bc
Peppigrande	15.7 a	0.6 bc	2.0 a	14,172 a
<i>Pr &gt; F</i>	<i>&lt;.0001</i>	<i>&lt;.0001</i>	<i>&lt;.0001</i>	<i>&lt;.0001</i>

<sup>z</sup> Means followed by the same letter are NOT significantly different at  $P = 0.05$ , Tukey-Kramer.



**Figure 1:** Percent of unmarketable fruit classified as fruit affected by blossom end rot (BER)



**Figure 2:** Percent of total number of fruit (marketable and unmarketable) classified as unmarketable



**Figure 3.** Crop progress, six weeks after transplanting.



**Figure 4.** Crop progress, nine weeks after transplanting



**Figure 5.** Var. Flavorburst, 13 weeks after transplanting.



**Figure 6.** Var. Cornito Arancia, 13 weeks after transplanting.



**Figure 7.** Fine cracks are developing on the fruit of pepper variety Turnpike.



**Figure 8.** Rind splitting on some fruits of pepper variety Regulator.



**Figure 9.** PS 09941819 (with X5R®)



**Figure 10.** Regulator



**Figure 11.** Turnpike (with X5R®)



**Figure 12.** Flavorburst



**Figure 13.** Sweet Sunrise



**Figure 14.** Cornito Giallo



**Figure 15.** Carmen

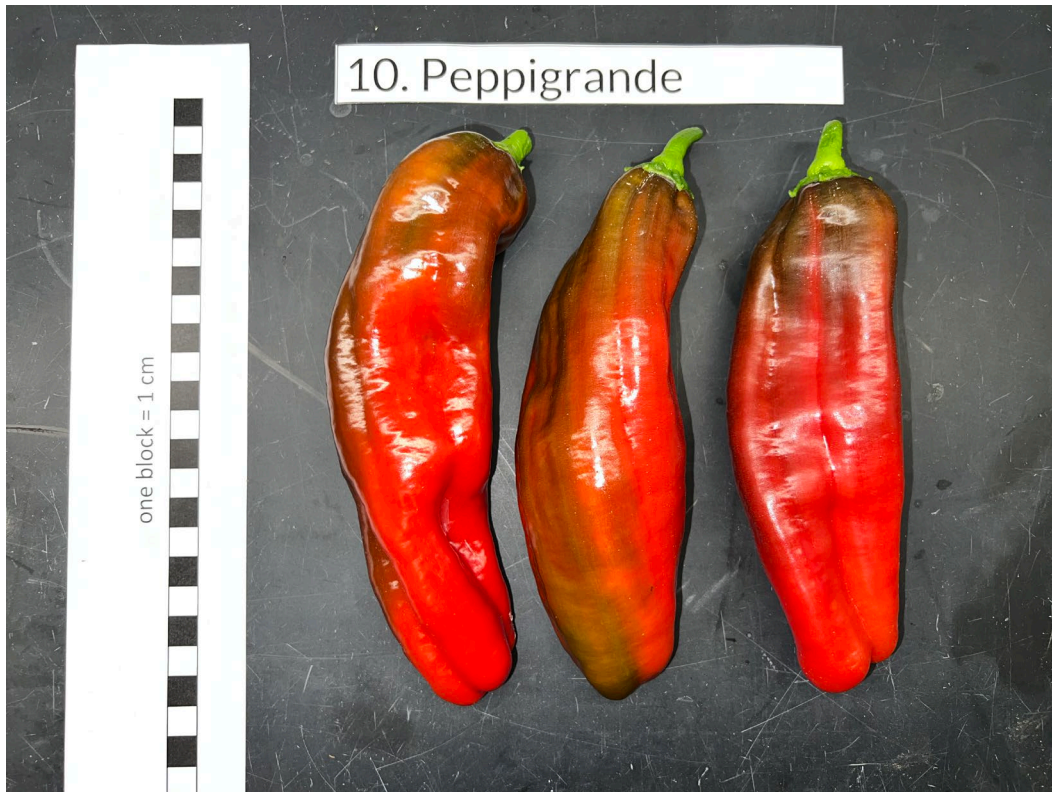


**Figure 16.** Mama Mia Giallo





**Figure 17.** Cornito Arancia



**Figure 18.** Peppigrande