

Organic Seed Partnership

Early CMV Resistant Red Bell Peppers 2007 Replicated Trial Report

OSP Pepper Trial Collaborators:

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As part of the Organic Seed Partnership (OSP) we evaluated bell pepper varieties and advanced breeding lines in replicated trials at Crimson Clover Farm in Bainbridge, NY, SANTEE Farm and Gardens in Wheeling, WV and Cornell University's Freeville Organic farm in Freeville, NY. These varieties included comparison varieties Early Red Sweet (OP), King of the North (OP), New Ace (hybrid) and 4-5 advanced CMV tolerant Cornell breeding lines (all OP's) at each site. This was the second year of replicated trails of Cornell's early red bell pepper breeding material (see Early CMV Resistant Red Bell Pepper 2006 Replicated Trial Report). All sites were either certified organic, or at the least managed organically. The objective of the trials was to compare newly developed peppers breeding lines from the Cornell organic pepper breeding program with standards used in organic production in a number of different locations to allow us to identify the best performing breeding lines with respect to overall performance and adaptation. These trials are part of the final assessments of a 5 year breeding program supported by both the USDA Organic Seed Partnership and the NE-SARE Collaborative Breeding for and in Organic Systems.

2007 Early CMV Resistant Red Bell Pepper Replicated Trial Summary:

We obtained a good assessment of how several organic standards, a new variety (Peacework), and several breeding lines did at three different sites. Good growing conditions prevailed at the Freeville, NY site, but adverse conditions (drought, disease) challenged the trials at both Crimson Clover and SANTEE Farm and Gardens.

Several generalizations can be made from the three sites:

- In these trials New Ace was the top performer at both the Freeville and Crimson Clover Farms with respect to yield, earliness and fruit size. There was no clear winner at SANTEE Farm and Gardens.
- Several of the experimental lines did well with respect to earliness, fruit size and yield in the Freeville trial, performing as well as or better than King of the North and Early Red Sweet. A number of these lines performed well in seed company trials as well and are now available in their catalogs:
 - NY06-329-4 'Peacework' <http://www.fedcoseeds.com/> and NY06-368B 'See You Early' <http://www.pumpkinvegetableorganicseeds.com/>.
- Early Red Sweet is a very early, prolific variety, but produces small red fruit with thin flesh.

Cornell University- Freeville Organic Vegetable Research Farm

Materials and Methods:

We evaluated 8 varieties in total - 3 were standard comparison varieties and 5 were newly developed Cornell lines. A number of these lines were progeny of top performers in the 2006 trials.

NY06-365A - progeny of NY05-454A-17, one of the top performers in the 2006 Freeville trial

NY06368B – progeny of NY05-460A-27, one of the top performers in the 2006 Freeville trial

NY06-329-4 – progeny of NY05-477D, similar to NY05-477E-9, one of the top performers in the 2006 OSU trial

Plants were started in the greenhouse on April 19th and transplanted to the field on June 7th, 2007. Each plot consisted of 12 plants planted in double rows on plastic covered 40” beds spaced 7’ apart. Plant spacing within rows was 16”. Prior to bed forming dairy compost was spread at a rate of 8.76 tons/ acre. Analysis of the compost indicated it was equivalent to 174 pounds of nitrogen per acre. At transplanting, each plant was watered in with a dilute fish emulsion. All beds had drip irrigation, but timely rain events prevented having to ever use it. No sprays were used to manage insects or disease.

Pepper harvest began as soon as the first ripe fruit were noticed on August 23rd, 11 weeks after transplant, but there was not an appreciable number of red fruit until September 6th, 13 weeks after transplant. Only red fruit were harvested each week. Number of fruit, total mass, and marketable mass were recorded for each plot. A representative fruit from each plot was measured each week for size (length x width) and wall thickness. Harvest continued each every week until there was a slight frost on October 16th. On the last harvest date all fruit were harvested including any remaining green fruit. The field was plowed in, but subsequently we had warm fall weather with no frost meaning we could have continued harvest ripening fruit.

Results

The summer of 2007 was overall a very good growing season and we largely avoided the drought conditions of other parts of the region. Late warm temperature provided good ripening conditions well into October. Overall, we had a successful pepper season with good yields of red fruit (Table 1). The standard New Ace had significantly higher yields than the rest of the varieties and breeding lines. This is in contrast to the 2006 trials where the top two breeding lines tested did as well as New Ace. All of the other varieties and breeding lines produced comparable total yields except for NY06-322-9FOF, which produced significantly less. With respect to marketable yield, NY06-365A did the best among the breeding lines and was equivalent to Early Red Sweet and King of the North, and all of the breeding lines except for NY06-322-9FOF did as well as King of the North.

Table 1. Red bell pepper yield, Cornell Organic Farm, Freeville, NY

Variety*	Total Fruit (#/plant)	Marketable Fruit (#/plant)	Total Yield (kg/plant)	Marketable Yield (kg/plant)
New Ace	8.3 b	6.9 b	1.14 a	0.99 a
Early Red Sweet	10.6 a	10.0 a	0.58 b	0.81 ab
King of the North	5.4 de	4.4 cd	0.82 b	0.70 bc
NY06-365A	5.8 cd	4.9 cd	0.73 bc	0.66 bc
NY06-329-4	4.0 e	3.6 de	0.65 bc	0.59 cd
NY06-368B	5.1 de	4.2 cde	0.60 bc	0.51 cd
NY06-303LH	7.1 bc	5.4 c	0.61 bc	0.48 cd
NY06-322-9FOF	3.8 e	2.7 e	0.55 c	0.41 d
LSD**	1.7	1.5	0.27	0.21

*Varieties sorted by Marketable Yield

**LSD: Least significant difference between two means. Means with the same letter are not significantly different from each other at $p \leq 0.05$.

With regard to fruit type, NY06-329-4 and NY06-322-9FOF had the blockiest and heaviest fruit with the most fruit thickness and were comparable to fruit of King of the North and New Ace (Table 2). With respect to earliness, after Early Red Sweet, NY06-303 LH was the earliest and comparable to New Ace. This was followed by NY06-329-4. There were no significant differences in flesh thickness amongst the varieties and breeding lines, except for Early Red Sweet, which produces a fairly thin fleshed fruit. Early Red Sweet proved once again to be the earliest producer (Figure 1). All the breeding lines were earlier or comparable to King of the North. NY06-303LH was the earliest and only lagged slightly behind New Ace.

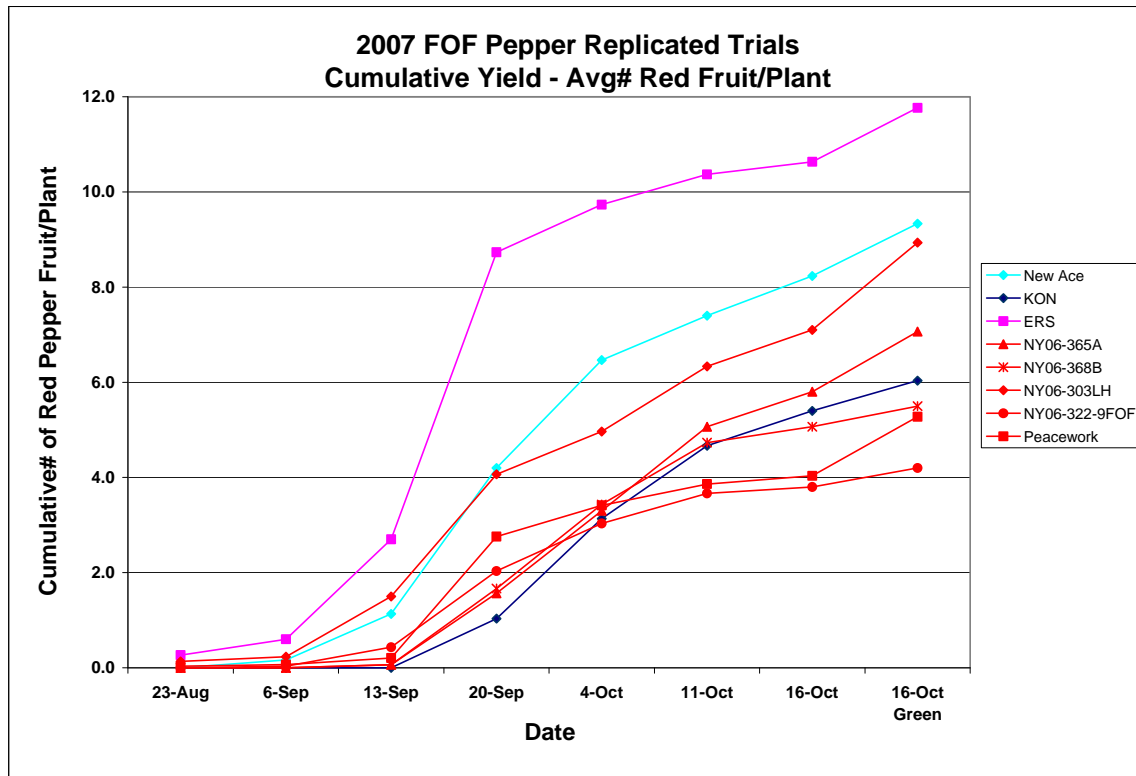
Table 2. Red bell pepper fruit characteristics, Cornell Organic Farm, Freeville NY

Variety*	Average Fruit Weight (g)	Average Length (cm)	Average Width (cm)	Fruit Size - Average Length x Average Width (cm)	Fruit Thickness (mm)
NY06-329-4	160.1 a	8.83 ab	8.32 a	73.6 a	5.33 a
New Ace	137.3 bcd	9.16 a	7.83 b	71.7 a	4.00 ab
NY06-322-9FOF	145.8 abc	8.93 ab	7.90 ab	70.7 ab	4.33 ab
King of the North	152.7 ab	8.39 bc	7.87 ab	66.1 ab	5.00 a
NY06-368B	118.6 d	8.32 bc	7.57 b	62.9 bc	4.25 ab
NY06-365A	125.5 cd	8.22 bc	7.01 c	57.7 cd	4.50 a
NY06-303LH	86.0 e	7.75 cd	6.41 d	49.8 de	4.13 ab
Early Red Sweet	79.8 e	7.03 d	6.91 c	48.6 e	3.00 b
LSD**	22.1	0.73	0.48	8.1	1.47

*Varieties sorted by Fruit Size

**LSD: Least significant difference between two means. Means with the same letter are not significantly different from each other at $p \leq 0.05$.

Figure 1. Red bell pepper earliness, Cornell Organic Farm, Freeville, NY



We had a good assessment of performance in 2007 at the Freeville, NY location. The results of this trial show that we have successfully improved upon yield, fruit type (fruit size, fruit weight, and fruit thickness) and earliness such that the CMV resistant breeding lines perform close to, equal to or sometimes better than the standards depending on the trait.

- In this trial New Ace had the best combination of good yield, earliness and fruit size.
- All the Cornell breeding lines yielded as well as King of the North except for NY06-322-9FOF. NY06-365A was the best performer with respect to yield and was equivalent to both King of the North Early Red Sweet.
- The overall winner for fruit size and thickness was NY06-329-4.
- As in the 2006 Freeville, NY trial, Early Red Sweet proved once again to be an early, prolific, but small red pepper with thin flesh.

To summarize the Freeville results for each breeding line:

NY06-303 LH- This line had a very light and small fruit (about the same as Early Red Sweet), but a great fruit thickness for its size (4.13mm). Average number of fruit was highest among breeding lines, but because of its small size it had a low total marketable yield. This was the earliest of the breeding lines.

NY06-322-9 FOF- This line had the third highest fruit weight (146 grams per fruit) in peppers we trialed and was not statistically different than New Ace and King of the North. The fruit was also blocky with average fruit thickness of 4.33mm. However, it had the worst yield of all the peppers we trialed.

NY06-329-4 - This line produced the blockiest and heaviest peppers (160 grams per fruit) of all the lines and varieties we compared in 2007. It also had the thickest flesh (5.33mm), but it was only a moderate yielder in terms of marketable yield (kg/plant) and marketable fruit (#/plant). NY06-329-4 was selected by Fedco Seeds as the best all around performer in their trials and was named 'Peacework', after Peacework Organic Farm in Newark, NY, where much of the selection for this pepper breeding project has been performed. Peacework is now available for sale in their catalog <http://www.fedcoseeds.com/>.

NY06-365A- Marketable fruit per plant and marketable yield were the highest amongst the breeding lines and was statistically equivalent to King of the North and Early Red Sweet. This line had average fruit weight and size with fruit thickness of 4.50 mm.

NY06-368B - This line had an average fruit weight, size and yields with fruit thickness of 4.25 mm. This line performed well in seed company trials and is now available as 'See You Early' from Outstanding Seeds <http://www.pumpkinvegetableorganicseeds.com/>.

Crimson Clover Farm, Bainbridge, NY

Materials and Methods:

Five varieties were evaluated in an on-farm-trial: New Ace, a hybrid variety recommended by organic growers; Early Red Sweet, an OP variety under trial by OSP grower-cooperators; and three OP Cornell lines developed for early fruit ripeness and CMV tolerance, NY06-368A, NY06-365A, and NY06-303LH.

Crimson Clover Farm is located on a tributary of the Susquehanna River at an elevation of 1500 ft. It falls within USDA Hardiness Zone 4b. The farm has been certified organic since 2004. The predominant soil at the trial site is Chenango channery silt loam. In 2006, the experimental area was planted to a cover crop of oats/red clover/crimson clover, followed by winter rye.

The experiment was designed as a randomized complete block with three replications that were superimposed on existing beds. Plots were 4 ft by 9 ft. Pepper transplants, raised in the Cornell organic greenhouse, were planted on June 10th, 2007. Peppers were planted in a double row with 16" between rows and 18" between plants within a row. Each plot contained 12 peppers. Each pepper was planted with 1.5 quarts of McEnroe compost. The experiment was irrigated twice by hand and hand weeded three times. No sprays were applied for insect pest or disease control. Black plastic is not used on this farm and was not used in this experiment.

Plots were evaluated for disease on September 16th, and the first red peppers harvested. Red peppers were harvested again on September 20th. Because frost was imminent, the experiment was harvested from September 28-29th by block for a third and final time of all peppers (red and green) that were whole. At each harvest, each pepper was weighed and measured for width. In addition, at the final harvest, the color of each pepper was recorded, and the wall thickness of five representative peppers per plot was measured.

Results:

The 2007 growing season was droughty, particularly during June-August. In addition, in early through mid July, the pepper plants were severely stunted and were slow to flower and set fruit. An adjacent planting of snap beans showed transient symptoms consistent with CMV, e.g., stunted plants and leaf curling and mottling. Pepper plants in mid-September had mottled leaves, but no disease symptoms were visible on fruit. The leaf mottling was widely present in all blocks and on all varieties.

Table 3. Bell pepper yield, Crimson Clover Farm, Bainbridge, NY

Variety*	Total Fruit (#/plant)	Marketable Red Fruit (#/plant)	Total Fruit (kg/plant)	Marketable Red Fruit (kg/plant)
New Ace	7.0 a	3.0 a	0.735 a	0.415 a
Early Red Sweet	7.4 a	2.0 ab	0.540 ab	0.210 b
NY06-365A	5.2 a	1.0 b	0.455 b	0.135 b
NY06-303LH	4.0 a	1.1 b	0.300 b	0.115 b
NY06-368A	3.4 a	0.6 b	0.365 b	0.080 b
LSD**	ns***	1.5	0.250	0.170

*Varieties sorted by Marketable Red Fruit

**LSD: Least significant difference between two means. Means with the same letter are not significantly different from each other at $p \leq 0.05$.

***Not significant

The 2007 pepper harvest was poor in comparison to previous years, probably due to lack of rainfall and possibly to disease. New Ace had the highest red pepper yield in terms of fruit weight produced per plant (Table 3). The yield advantage was considerable: weight of red fruit of New Ace was from 2 to 5 times greater than that of the other varieties. New Ace and Early Red Sweet had the greatest number of red fruits per plant. New Ace was also the first variety to produce mature red fruit, although only four days before other varieties (data not shown). Individual fruit weight did not differ between New Ace, NY06-368A, and NY06-365A, which were all significantly heavier than the individual fruit of NY06-303 LH and Early Red Sweet (Table 4). New Ace fruit had significantly greater width than the other varieties. Fruit wall thickness didn't differ significantly between varieties.

Table 4. Bell pepper fruit characteristics, Crimson Clover Farm, Bainbridge, NY

Variety*	Average Marketable Red Fruit Weight (g)	Average Marketable Red Fruit Width (cm)	Fruit Wall Thickness (mm)
New Ace	140 a	7.7 a	5 a
NY06-365A	130 a	7.2 b	5 a
Early Red Sweet	100 b	7.2 b	4 a
NY06-303 LH	105 b	6.7 c	5 a
NY06-368A	130 a	6.9 bc	5 a
LSD**	15	0.3	ns***

*Varieties sorted by Marketable Red Fruit Width

**LSD: Least significant difference between two means. Means with the same letter are not significantly different from each other at $p \leq 0.05$.

***Not significant

The results support the observations of organic growers in short-season areas that New Ace is a reliable red bell pepper variety. A drawback to its use is that organically produced seed of New Ace is not currently available. In addition, since it is a hybrid, growers cannot save seed of this variety. Under droughty conditions and possibly CMV infection, Early Red Sweet, as well as the experimental lines NY06-368A, NY06-365A, and NY06-303 LH, performed poorly.

SANTEE Farm and Gardens, Wheeling, WV

Materials and Methods:

Eight varieties were evaluated in this trial - 3 were standard comparison varieties and 5 were newly developed Cornell lines, the same varieties that were evaluated at the Freeville, NY location. This trial was planted at the Sustainable Agricultural Network for Training and Environmental Education (SANTEE) Farm and Gardens outside Wheeling, WV <http://www.farmeducation.org/index.htm>. SANTEE Farm and Gardens is both a working organic farm and educational center combined.

Results:

There were problems with excessive heat and drought in July and August. There was quite a lot of variation in the data and no significant differences were found between the varieties with respect to #fruit, yield fruit and fruit weight (Tables 5 and 6). However, despite the adverse conditions these parameters were, in general, comparable or better to those obtained in the 2007 Cornell Freeville Organic Farm trial. Differences in cultural conditions (e.g. fertility) may account for this observation. Cornell lines NY06-368B and NY06-322-9 produced the largest fruit, which was equivalent to fruit produced by New Ace. The other 4 Cornell lines produced fruit that was comparable to King of the North. The Cornell lines also produced fruit with flesh that was equivalent or better than New Ace and King of the North. With respect to earliness, Early Red Sweet led the pack (Figure 2). All Cornell lines were comparable to New Ace and King of the North except for NY06-329-4, which lagged behind all of the others.

Table 5. Red bell pepper yield, WVSU

Variety*	Total Fruit (#/plant)	Marketable Fruit (#/plant)	Total Yield (kg/plant)	Marketable Yield (kg/plant)
NY06-365A	10.5 a	8.1 a	1.27 a	1.08 a
New Ace	8.4 a	7.0 a	1.21 a	1.06 a
King of the North	8.4 a	6.6 a	1.14 a	0.94 a
NY06-322-9	9.0 a	5.8 a	1.28 a	0.90 a
Early Red Sweet	11.1 a	8.3 a	1.08 a	0.84 a
NY06-368B	8.6 a	6.3 a	1.11 a	0.82 a
NY06-303LH	7.6 a	4.5 a	0.79 a	0.54 a
NY06-329-4	5.6 a	3.4 a	0.70 a	0.50 a
LSD**	ns***	ns	ns	ns

*Varieties sorted by Marketable Yield

**LSD: Least significant difference between two means. Means with the same letter are not significantly different from each other at $p \leq 0.05$.

***Not significant

Table 6. Red bell pepper fruit characteristics, WVSU

Variety*	Average Fruit Weight (g)	Average Length (cm)	Average Width (cm)	Average Length x Average Width	Fruit Thickness (mm)
Early Red Sweet	102.7 a	6.6 e	6.3 d	42.0 d	2.44 c
NY06-303LH	108.2 a	8.4 abc	6.5 cd	53.8 c	3.22 bc
NY06-365A	124.2 a	8.1 bcd	7.0 abcd	56.2 bc	3.78 ab
King of the North	139.0 a	7.3 cde	7.7 ab	56.3 bc	3.17 bc
NY06-329-4	147.0 a	7.2 de	8.0 a	57.1 bc	4.33 a
NY06-322-9	145.3 a	8.6 ab	7.4 abc	63.6 ab	4.22 a
New Ace	137.9 a	8.2 bcd	7.8 ab	64.3 ab	3.78 ab
NY06-368B	120.8 a	9.6 a	6.8 bcd	66.2 a	3.22 bc
LSD**	ns***	1.2	1.0	8.9	0.81

* Varieties sorted by Average Length x Average Width

**LSD: Least significant difference between two means. Means with the same letter are not significantly different from each other at $p \leq 0.05$.

***Not significant

Figure 2. Red bell pepper earliness, WVSU Organic Farm

