Bell Pepper Cultivar Evaluation, Central Kentucky, 2018

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Bell peppers have been a profitable crop in Kentucky for many years. During this time bacterial spot has continued to reduce yields, because the species of bacteria causing this disease keeps evolving, allowing it to overcome bacterial spot resistance bred into the latest bell pepper cultivars. Consequently, bacterial spot resistance is a major selling point for new cultivars. Some of the newer ones have resistance to ten races (genetic variants) of *Xanthomonas campestris*, the species of bacteria responsible for most cases of pepper bacterial spot, while 'Aristotle' has resistance to three (Table 3). Resistance to a greater number of races reduces disease and can reduce the number of bactericide sprays, but the cultivars still have to yield well and have the quality that buyers require. Bell pepper breeders have developed cultivars producing a large number of U.S. Fancy grade peppers; however growers that sell to wholesalers who market fruit at a fixed price prefer cultivars that produce large percentages of U.S. Number 1 fruit. This replicated trial evaluated 15 bacterial spot-resistant bell pepper cultivars in comparison to the industry standard, 'Aristotle'.

Materials and Methods

Cultivars were seeded on 21 March into plastic plug trays (72 cells per tray) filled with Jiffy Seed Starting Mix 17 (Jiffy Products of America, Lorain, OH) at the University of Kentucky Horticultural Research Farm in Lexington. Greenhouse-grown transplants were set into black-plastic-covered, raised beds of Maury silt loam using a water wheel setter on 14 May. Plots were replicated four times in a randomized block design. Each plot was 10 ft. long and contained 20 plants set 12 in. apart in double rows spaced 15 inches apart on the bed. Beds were 5 ft. apart. Fifty pounds of nitrogen/acre as urea were applied prior to plastic laying. At planting each transplant was watered in with a pint of starter solution (6 lb. of 10-30-20 in 100 gallons of water). Calcium nitrate was applied via fertigation roughly weekly at a rate of 3.9 lbs. nitrogen/acre from 1 June through 9 September, for a total of 44 lbs. N/acre. No bactericide or fungicide sprays were applied, in order to better evaluate bacterial spot resistance. Danitol was sprayed for stink bug control on 9 and 15 August. Seven plants per plot were rated for disease severity using the Horsfall-Barratt scale, where each plant is given a numerical value depending on the total percent leaf area affected by bacterial spot.

The plot was harvested five times: 28 June, 16 July, 8 August, and 6 and 27 September. Fruit were weighed, counted and graded according to the grades U.S. Fancy (>3 in. diameter and height), U.S. No. 1 (>2.5 in. but <3 in. diameter), and U.S. No. 2 (<2.5 in. diameter plus misshapen but sound fruit sold as 'choppers' to food service buyers), and cull fruit.

Results and Discussion

Average monthly temperatures during this trial began with May being 7 °F above normal. June was 3 °F above normal. July and August were near normal, and September was 5 °F above normal. Precipitation was about normal in May and July, and 1.8, 1.3, and 4.7 inches above

normal in June, August, and September, respectively. There were 24 days with precipitation from the planting date through 9 July (the last disease evaluation date). This many precipitation events are about average for that period. 'PS 8302' seeds germinated very slowly and the germination percentage was low. Consequently, there were only enough transplants to make three, instead of four trial replicates. A windy storm on 20 July broke many pepper-laden branches. This contributed to the high number of sun-scalded peppers. Foliage density appeared to vary among cultivars, and this likely contributed to the high scald incidence as well.

Most cultivars performed well with respect to yield (Table 1) and desirable fruit characteristics (Table 2). The best performing cultivars were selected by evaluating yield, slight differences in fruit characteristics, and for a few cultivars, past performance. Tables 4, 5, and 6 show results, by grade, of the early, middle, and latest harvests, respectively. This gives growers an idea of how the cultivars performed across the harvest period. (Most cultivars yielded little or nothing in the first harvest). The second and fifth harvests (Tables 4 and 6) yielded the most pounds of fruit across all cultivars, and were about equal. The third harvest (Table 5) produced about a quarter of the second harvest. This may have been due to very low fruit set observed in many cultivars in late June. Yields of the ten highest-yielding cultivars (total marketable yield) were not significantly different (Table 1). All ten also had the greatest yields of U.S. Fancy fruit, and these yields, too, were statistically similar. Eight of these also had the highest yields of U.S. No. 1 fruit. The best performing bell pepper cultivars in this trial were among this group:

- 'La Belle' had the highest total marketable yield for the entire trial and the second highest U.S. Fancy yield. It also had relatively low percentages of culled and sun-scalded fruit (Table 2), and one of the higher percentages of four-lobed fruit. Across all harvests, it had one of the lower average weights of individual fruit in the U.S. No. 1 grade, and maintained this trend throughout the trial (Table 8). Its 80% pack out of Fancy + No.1 fruit in the second harvest (Table 7) makes it a good choice for the early market, however it tends to have a lighter fruit color and had the highest percentage of fruit with silvering (very fine, pale streaks on the skin).
- 'Aristotle' had the second highest total marketable yield, as it did in the 2017 pepper evaluation (Smigell et al, 2017). Essentially, 'La Belle' and 'Aristotle' had the same total marketable yields (26.5 tons/A). 'Aristotle' had a high average weight of individual fruit in the U.S. No. 1 grade across all harvests (Table 8). It had low scald, cull, and silvering percentages, however its percentages of four-lobed fruit have been among the lowest of all cultivars tested in this year's and last year's trials.
- 'Samurai S10' had the highest yield of No.1 fruit for the trial and the second highest percentage of total yield as Fancy + No. 1 fruit. It ranked very high in percentage of Fancy + No. 1 fruit in the second and third harvests (Table 7), making it a good cultivar for the early market. Its average weight of individual fruit in the U.S. No. 1 grade across all harvests was not significantly different from 'Aristotle' (Table 8). Cull, silvering, and scald percentages were among the lowest. It also had high rankings for all other fruit characteristics.
- 'Turnpike' ranked highest for percentage of Fancy + No. 1 fruit pack out in the last harvest, and so may be a good choice for the later market. Its overall percentage of total yield as Fancy + No. 1 fruit was higher than for 'La Belle' and 'Aristotle'. It had a low silvering percentage, good blockiness and color ratings, and was the highest

yielder of marketable fruit in the 2017 trial. It maintained a high average fruit weight for the No. 1 grade across all harvests (Table 8).

- 'Boca' was among the highest yielders in 2017 and in this year's trial. It had the second highest overall yield of No. 1 fruit and a high percentage of Fancy + No. 1 fruit in the second harvest, consistent with its early harvest last year. Thus this is another good early market candidate. Its overall percentage of total yield as Fancy + No. 1 fruit was higher than for 'La Belle' and 'Aristotle'. Silvering percentage was low, and cull and sunscald percentages were very low. It was rated very high for fruit appearance and its dark green color.
- 'Captiva' had the third highest yield of No. 1 fruit for the whole trial, and the highest percentage of total yield as Fancy + No. 1 fruit for the trial. It had the highest percentage (88%) of Fancy + No. 1 fruit in the second harvest, making it a good early market choice. Cull and scald percentages were low, and it had some of the highest marks for fruit shape, appearance, blockiness, and color.

Yields of U.S. Fancy and No. 1 peppers (as a percentage of total marketable yield) decreased for all cultivars from the second to the third harvest (Table 7), and for most cultivars the percentage decreased again in the last harvest, except for 'Playmaker', 'Captiva', 'Outsider' and 'Turnpike'.

Maintaining individual pepper weight/size as the season progresses is desirable, but normally drops as the season progresses. Looking at all cultivars combined, just for the Fancy and No. 1 grades, average pepper weights were significantly lower for the later harvests compared to harvests in June or July (data not shown). Thus, on the whole, pepper size for these grades decreased as the season progressed. Comparing cultivars, all harvests combined, there were no significant differences in the average weight of a Fancy pepper (Table 8). Analysis of variance did indicate that the average weight of peppers in the No. 1 size grade differed among harvest dates for some cultivars (column 5, Table 8). 'Turnpike' was the only cultivar among the overall high-yielders that did not vary its average weight of No. 1 peppers through all five harvests.

In Figure 1 the vertical axis represents the average bacterial spot severity by cultivar after transforming the Horsfall-Barratt ratings to the midpoint of the rating range. Ratings were completed on 15 and 27 June, and 9 July. By the third evaluation, 'Hunter', 'PS 8302', 'Turnpike', 'Captiva' and 'Boca' showed trends of higher bacterial spot severity, and were statistically different from the grower standard 'Aristotle'. Though 'Samurai S10' was numerically lowest in bacterial spot on all dates, this difference was not statistically different from most cultivars. These levels of disease were still relatively low, as very few fruit were culled due to bacterial spot, and leaf spotting was not severe enough to become obvious in any cultivar.

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Table 1. Total yield and yield by USDA grades, 2018.

Cultivar	Total Marketable Yld (lb/A)[1,2]		U.S. Fancy (lb/A)[2,3]		U.S. No. 1 (lb/A)[2,4]		U.S. No. 2 (lb/A)[2,5]		Cull (%)[6]	Fancy + No. 1 as % of Total Mkt Yield
La Belle	53,200	a	19100	a	14100	abc	20000	a	10	62
Aristotle	53,000	a	19500	a	13900	abc	19500	a	9	63
Playmaker	48,400	ab	16900	ab	14200	abc	17200	abcde	11	65
PS 0994-1819	46,900	abc	19100	a	10000	c	17800	abc	11	62
SV 9325	44,500	abc	15000	abc	10900	bc	18600	ab	13	58
Ninja S10	44,300	abc	15000	abc	11800	abc	17600	abcd	15	60
Samurai S10	43,900	abcd	14900	abc	16400	a	12600	cdef	10	71
Turnpike	43,700	abcd	16400	ab	13300	abc	14000	bcdef	16	68
Boca	43,600	abcd	14600	abc	15700	ab	13300	bcdef	10	69
Captiva	43,200	abcd	15600	abc	15500	ab	12000	ef	11	72
SDY 48	40,400	bcd	11700	bc	12600	abc	16000	a-f	14	60
Outsider	39,300	bcd	16600	ab	9700	c	13100	cdef	22	67
Standout	37,700	bcd	14200	abc	10700	bc	12900	cdef	16	67
Skyhawk	36,400	bcd	10500	bc	12400	abc	13600	bcdef	12	63
Hunter	35,000	cd	9000	c	13900	abc	12100	def	9	66
PS 8302	32,100	d	11400	bc	9100	c	11600	f	24	64

[1]Includes yields of U.S. Fancy, No. 1, and No. 2 fruits.
[2]Means in the same column followed by the same letters are not significantly different (Waller-Duncan test LSD $P \leq .05$).
[3]U.S. Fancy = undamaged, unblemished, well-shaped fruit >3 in. dia. and height.
[4]No. 1 = undamaged, unblemished, well-shaped fruit >2.5 but <3 in. dia.
[5]No. 2 = undamaged, unblemished fruit <2.5 in. dia., plus larger, misshapen yet sound fruit which could be sold as 'choppers' to food service buyers.
[6] Percent of all harvested fruit (by weight) having surface scarring, sunscald, insect and disease damage.

Table 2. Fruit characteristic ratings.

Cultivar	Silvering (%)[1]	Uniform Fruit Shape[2]	Fruit Appear-ance[2]	4-lobed Fruit (%)	Blocki-ness[3]	Green Color[4]	Sun-scalded Fruit (%)[5,6]	
La Belle	11	4	4	60	4.2	4.2	5	a
Aristotle	5	4.1	4.2	33	4.4	4.1	4	a
Playmaker	3	4	3.9	60	4.3	3.6	6	abcd
PS 0994-1819	5	4	4.1	50	4.4	4.3	5	ab
SV 9325	1	3.9	4.1	45	4.2	4.4	9	bcde
Ninja S10	5	4	4	60	4.2	4.2	10	ef
Samurai S10	3	4.4	4.3	60	4.5	4.4	5	a
Turnpike	6	3.9	4.1	53	4.4	4.3	9	cde
Boca	5	4.2	4.3	50	4.2	4.4	4	a
Captiva	8	4.5	4.4	50	4.6	4.5	6	abc
SDY 48	8	4.1	4.1	58	4.4	4.4	9	bcde
Outsider	9	4.2	4.3	63	4.5	4.3	13	f
Standout	1	4.3	4.4	55	4.4	4.4	10	def
Skyhawk	5	4.1	4	43	3.9	4.1	5	a
Hunter	10	4.1	3.9	33	3.9	4.5	4	a
PS 8302	4	4.3	4.1	50	4.4	4.4	17	g

[1]Percent of total marketable fruit count at 2nd harvest showing silvering (very fine, light-colored streaking).
[2]1 = poor, 5 = excellent.
[3]1 = long, slender fruit or very squat, flattened fruit, 5 = fruit with equal height and width.
[4]1 = pale green, 5 = dark green.
[5]Percent of all harvested fruit (by count) having sunscald.
[6]Means in the same column followed by the same letters are not significantly different (Waller-Duncan test LSD $P \leq .05$).

Table 3. Cultivar attributes.

Cultivar	Seed Source	Days to Harvest[1]	Ripe Color	Disease Resistances[2,3]	Fruit Comments
La Belle	SW	73	red	HR: BS 1-10	Many jumbo fruit; many distorted fruit; a few flattened fruit in last harvest
Aristotle	ST	70-75	red	IR: BS (1-3), PVY, TMV	Many distorted fruit; a few flat fruit, and lighter green
Playmaker	SW	71	red	BLS 0-10 HR: TMV; IR: Phyt	Many lopsided/distorted fruit; attractive fruit in last harvest; a few flat fruit in last harvest
PS 09940-1819	SW	73	red	HR: BS 1-5; IR: Pc	Many jumbo fruit; 12 flattened fruit in last harvest
SV 9325	SW	-	red	HR: BS 1-10	Many flat fruit in last harvest; many tiny/lopsided ones at last harvest
Ninja S10	SW	72	red	IR: BS 1-10; HR: TMV	
Samurai S10	SW	72	red	IR: BS 1-10; HR: TMV	Few very large fruit in last harvest
Turnpike	SW	75	red	HR: BS (1-5, 7-9), TMV, Phyt	A lot of tall fruit, many pointy fruit; many jumbo sized & attractive fruit in last harvest 6 pointy; nice & tall
Boca	SW	73	red	HR: BS 1-10	Few very large fruit and a few flattened fruit in last harvest
Captiva	SW	-	red	HR: BS 1-10; IR:TSWV	Attractive fruit in last harvest; dark green fruit
SDY 48	SW	73	red	HR: BS 1-10	Many flat ones in last harvest
Outsider	SW	73	red	HR: BS 1-10	Many very large fruit in last harvest
Standout	SW	-	red	HR: BS 1-10	Many flattened fruit; and many tiny fruit in last harvest
Skyhawk	SW	72	red	HR: BS 1-10	Many distorted fruit; many flattened fruit in last harvest
Hunter	SW	71	red	HR: BS 1-5, 7-9, TEV, TMV	Not many very large fruit; blocky, dense
PS 8302	SW	-	red	HR: BS 1-5	Several very large fruit in last harvest

[1]Days to harvest as listed by seed companies.

[2]HR = highly disease resistant (restricted disease development & symptoms); IR = intermediate resistance (may show more disease symptoms than 'resistant' cultivars grown in same environment).

[3]BS = bacterial spot (strains 1-10); Phyt = phytophthora root rot; TMV = tobacco mosaic virus; PVY = potato virus Y (strains 0, 1, and 1-2); TSWV = tomato spotted wilt virus: TEV = tobacco etch virus.

Table 4. Yields of second harvest, 16 July.

		Percent of Total Mkt. Yield		
Cultivar	**Total Marketable Yield (lb/A)[1]**	**Fancy (%)**	**No. 1 (%)**	**No. 2 (%)**
Aristotle	22125	57	17	26
La Belle	18667	60	21	20
Playmaker	16344	53	17	29
Standout	15210	67	23	11
SV 9325	14665	68	16	16
Skyhawk	14293	60	25	16
Samurai S10	13994	64	22	14
Ninja S10	13954	59	22	18
SDY 48	12841	62	16	22
Turnpike	12315	54	22	23
PS 0994-1819	12297	61	9	30
Outsider	12269	74	8	18
Boca	11963	62	19	20
Captiva	11915	68	20	12
Hunter	8349	61	26	14
PS 8302	7962	66	11	22

[1]Combined weights of Fancy, No. 1 and No. 2 fruit.

Table 5. Yields of third (middle) harvest, 8 August.

		Percent of Total Mkt. Yield		
Cultivar	**Total Marketable Yield (lb/A)[1]**	**Fancy (%)**	**No. 1 (%)**	**No. 2 (%)**
La Belle	7196	41	16	43
PS 0994-1819	6307	42	16	43
Standout	4447	45	22	34
SV 9325	4102	33	20	47
Aristotle	3975	40	11	49
Playmaker	3911	15	29	55
SDY 48	3539	27	28	45
Ninja S10	3267	24	25	52
Outsider	3122	44	4	52
Captiva	2949	16	47	37
Skyhawk	2868	29	23	48
Samurai S10	2605	38	29	33
Hunter	2251	45	27	28
Boca	2105	36	32	32
Turnpike	2006	28	30	42
PS 8302	1912	35	31	33

[1]Combined weights of Fancy, No. 1 and No. 2 fruit.

Table 6. Yields of fifth (last) harvest, 27 September.

		Percent of Total Mkt. Yield		
Cultivar	**Total Marketable Yield (lb/A)[1]**	**Fancy (%)**	**No. 1 (%)**	**No. 2 (%)**
Ninja S10	18695	20	29	52
La Belle	17950	14	32	53
Aristotle	16789	16	29	55
Boca	15663	14	44	42
Turnpike	15128	31	34	34
Playmaker	14720	25	29	45
Samurai S10	14620	16	35	49
PS 8302	14450	23	33	44
PS 0994-1819	14393	24	26	50
Captiva	14366	25	40	36
SV 9325	14320	8	26	67
Hunter	13821	9	44	47
Skyhawk	12787	8	37	55
Outsider	12142	23	38	40
SDY 48	11616	10	36	54
Standout	10373	8	33	59

[1]Combined weights of Fancy, No. 1 and No. 2 fruit.

Table 7. Combined percentages of U.S. Fancy and No.1 fruit at each harvest.

	% of U.S. Fancy + No. 1 Fruit[2]		
Cultivar[1]	**2nd Harvest**	**3rd Harvest**	**5th Harvest**
La Belle	80	57	47
Aristotle	74	51	45
Playmaker	71	45	55
PS 0994-1819	70	57	50
SV 9325	84	53	33
Ninja S10	82	48	48
Samurai S10	86	67	51
Turnpike	77	58	66
Boca	80	68	58
Captiva	88	63	64
SDY 48	78	55	46
Outsider	82	48	60
Standout	89	66	41
Skyhawk	84	52	45
Hunter	86	72	53
PS 8302	78	67	56

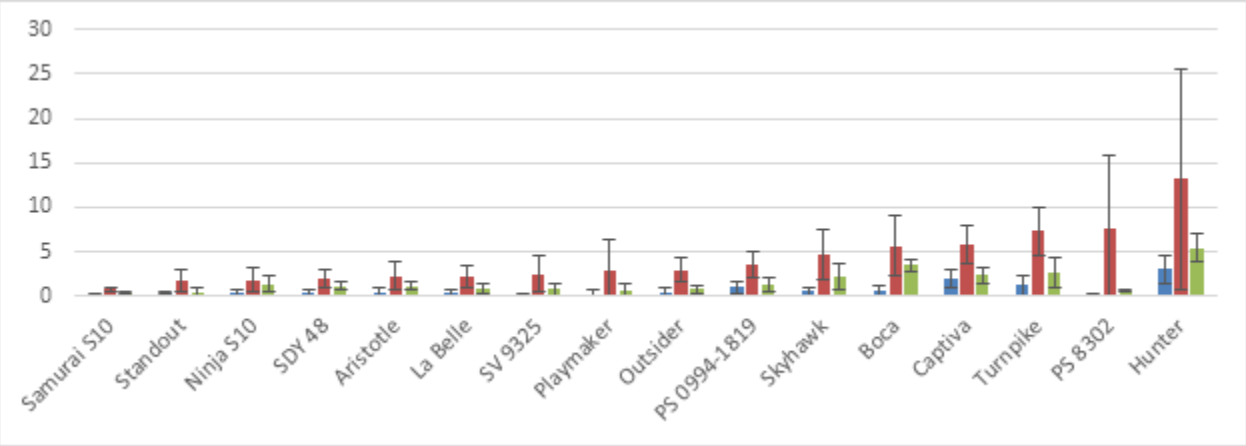
[1]Ranked by total-season yield.
[2]% of total marketable yields.

Table 8. Average pepper weights, all harvests combined[1].

Cultivar	All Marketable Peppers (lbs/pepper)		Fancy (lbs/pepper)		No. 1 (lbs/pepper)		Did U.S. No. 1 avg. wt. vary among harvests?
Aristotle	0.4	abcd	0.48	a	0.35	abc	yes
Boca	0.38	abcd	0.48	a	0.33	abcd	yes
Captiva	0.4	abcd	0.48	a	0.35	ab	yes
Hunter	0.37	abcd	0.46	a	0.32	bcd	yes
La Belle	0.38	abcd	0.46	a	0.3	d	no
Ninja S10	0.38	abcd	0.54	a	0.3	d	no
Outsider	0.4	abcd	0.46	a	0.32	cd	no
Playmaker	0.41	ab	0.47	a	0.36	a	yes
PS 0994-1819	0.4	abc	0.48	a	0.32	bcd	yes
PS 8302	0.41	a	0.51	a	0.3	d	yes
Samurai S10	0.36	d	0.42	a	0.33	abcd	yes
SDY 48	0.36	cd	0.43	a	0.32	cd	no
Skyhawk	0.34	e	0.49	a	0.33	abcd	yes
Standout	0.37	abcd	0.45	a	0.33	abcd	yes
SV 9325	0.36	bcde	0.46	a	0.33	abcd	yes
Turnpike	0.39	abcde	0.49	a	0.34	abc	no

[1]Means within a column followed by the same letter are not significantly different as determined by Duncan's New Multiple Range Test ($P \leq 0.05$)

Figure 1. Bacterial spot disease severity ratings[1].



[1]Seven plants per plot were rated for disease severity using the Horsfall-Barratt scale, where each plant is given a numerical value depending on the total percent leaf area affected. The vertical axis represents the avg. bacterial spot severity by cultivar after transforming the Horsfall-Barratt ratings to the midpoint of the rating range. Ratings were completed on 15 and 27 June, and 9 July (blue, orange, green bars, respectively).