

Evaluation of pepper breeding lines and cultivars for tolerance to the crown rot phase of *Phytophthora* blight and development of skin separation or 'silvering' in fruit, 2015.

This experiment, arranged as a randomized complete block design with 4 replications, was conducted in a field with a history of *Phytophthora* blight (*P. capsici*) at the Rutgers Agricultural Research and Extension Center (RAREC), Bridgeton, New Jersey. All peppers were grown by a local transplant producer located in Vineland, NJ. On 8 Jun, bell pepper breeding lines or cultivars were hand transplanted into double rows (18 in. in row) on black plastic mulch on 5-ft-centers (18 plants per plot) with drip irrigation. All treatment plots were 15-ft-long with *Phytophthora*-susceptible bell pepper 'Tomcat' planted in 5-ft breaks between plots. Fertility schedule and management of insect and weeds were done according to local recommendation guidelines. Each week, the number of *Phytophthora*-infected plants (out of a total number of 18) were counted and recorded from each 15-ft plot. All mature pepper fruit from 15-ft of each treatment row were harvested on 14 and 24 Aug.; 2, 14, and 21 Sep.; and 1 and 14 Oct. for a total of 7 harvests. All fruit were graded, separated and weighed for statistical analysis. Area Under Disease Progress Curve (AUDPC) values based on the percentage of plants killed by week per plot by *P. capsici* during the trial were calculated. Rainfall (in.) for the months of Jun, Jul, Aug, and Sep were ~12.5, 3.2, 2.6, and 3.0 in., respectively.

The number of boxes of extra-large, large, and medium-sized fruit, and total boxes of fruit per acre varied significantly between cultivars and breeding lines by harvest date (Tables 1-8). Total marketable boxes per acre was highest in Archemidis (1053 boxes per A); 9009 (893); Revolution (881) and Turnpike (833) (Table 8). Total number of extra-large boxes/A was highest in Turnpike (210), Archemidis (151), and Declaration (125) (Table 8). Total number of large boxes/A was highest in Archemidis (680), Revolution (646), and 9009 (626) (Table 8). Total percentage of fruit with 'silvering' ranged from 34 to 72% and varied significantly among cultivars and breeding lines (Table 8).

The total percentages of plants killed by *P. capsici* by week were calculated for each cultivar/breeding line and ranged from 33 to 75% (Table 9; Fig. 1). Cultivars and breeding lines with the fewest plants killed by *P. capsici* during the production season included Intruder (33%), Archemidis (36%), and Revolution (38%) (Table 9). Importantly, plant death caused by *P. capsici* was considered extremely high in *Phytophthora*-resistant lines Aristotle (39%) and Paladin (56%) which generally perform much better in this annual trial at RAREC. The trend of resistance/tolerance in some of our more widely-grown cultivars breaking down due to *P. capsici* in this trial continues to increase at RAREC. AUDPC values based on the percentage of plants killed by *P. capsici* by week varied significantly among cultivars and breeding lines (Tables 8; Figure 2).

Table 1. Number of 28-lb boxes per acre of extra-large, large-, and medium-sized fruit, total marketable boxes per acre, and percentage of marketable fruit with 'silvering' at harvest 1 on 14 Aug. at the Rutgers Agricultural Research and Extension Center in 2015.

Cultivar / BL	Number of boxes per acre ^z			Marketable boxes/A ^y	Marketable fruit with silvering (%) ^x
	Extra-large	Large	Medium		
9504	14 a ^v	45 a	0 c	60 a	64
Alliance	13 a	34 ab	5 ab	52 ab	7
Declaration	19 a	21 abc	1 c	41 abc	35
1718	20 a	21 abc	0 c	41 abc	19
Archemidis	4 a	31 abc	2 bc	35 a-d	61
9009	5 a	27 abc	0 c	32 a-d	100
Revolution	3 a	27 abc	0 c	30 a-d	54
Snapper	0 a	25 abc	0 c	25 a-d	75
Aristotle X3R	6 a	12 bc	2 bc	19 a-d	87
Paladin	0 a	7 bc	6 a	13 bcd	33
Tomcat	0 a	6 bc	0 c	6 cd	50
1819	3 a	2 c	0 c	6 cd	100
Karisma	0 a	0 c	0 c	0 d	0
Intruder	0 a	0 c	0 c	0 d	0
Camelot	0 a	0 c	0 c	0 d	0

^z Number of extra-large (>0.5 lb) sized fruit, large (.33-.49 lb) sized fruit, and medium-sized (.25-.32 lb) boxes per acre.

^y Total number of marketable (extra-large, large, and medium) boxes (28 lb) per acre.

^x Percentage of harvested fruit with 'silvering'. Only the means are presented.

^v Fisher's Least Significant Difference (LSD) test ($P=0.05$)

Table 2. Number of 28-lb boxes per acre of extra-large, large-, and medium-sized fruit, total marketable boxes per acre, and percentage of marketable fruit with 'silvering' at harvest 2 on 24 Aug. at the Rutgers Agricultural Research and Extension Center in 2015.

Cultivar / BL	Number of boxes per acre ^z			Marketable boxes/A ^y	Marketable fruit with silvering (%) ^x
	Extra-large	Large	Medium		
9009	15 ab ^v	46 a	5 ab	65 a	88
9504	27 a	32 abc	5 ab	64 ab	69
Archemidis	15 ab	33 abc	3 ab	51 abc	93
Declaration	18 ab	30 abc	3 ab	51 abc	49
Aristotle X3R	3 b	43 ab	3 ab	49 abc	74
1718	11 ab	24 abc	6 ab	42 abc	79
Revolution	7 b	24 abc	6 ab	37 abc	50
Tomcat	0 b	27 abc	8 a	35 abc	100
Alliance	4 b	22 abc	4 ab	30 abc	50
Intruder	0 b	10 bc	0 b	10 bc	100
Snapper	0 b	9 bc	0 b	9 bc	50
1819	0 b	4 c	0 b	4 c	100
Karisma	0 b	2 c	0 b	2 c	100
Paladin	0 b	0 c	0 b	0 c	0
Camelot	0 b	0 c	0 b	0 c	0

^z Number of extra-large (>0.5 lb) sized fruit, large (.33-.49 lb) sized fruit, and medium-sized (.25-.32 lb) boxes per acre.

^y Total number of marketable (extra-large, large, and medium) boxes (28 lb) per acre.

^x Percentage of harvested fruit with 'silvering'. Only the means are presented.

^v Fisher's Least Significant Difference (LSD) test ($P=0.05$)

Table 3. Number of 28-lb boxes per acre of extra-large, large-, and medium-sized fruit, total marketable boxes per acre, and percentage of marketable fruit with 'silvering' at harvest 3 on 2 Sep. at the Rutgers Agricultural Research and Extension Center in 2015.

Cultivar / BL	Number of boxes per acre ^z			Marketable boxes/A ^y	Marketable fruit with silvering (%) ^x
	Extra-large	Large	Medium		
Archemidis	16 a	143 a ^v	58 a	217 a	63 ab
9009	12 a	126 ab	50 ab	187 ab	59 ab
Aristotle X3R	8 a	82 abc	22 abc	112 abc	72 a
Revolution	3 a	90 abc	18 bc	110 abc	67 a
9504	13 a	82 abc	11 bc	106 abc	66 ab
Tomcat	11 a	78 abcd	16 bc	104 abc	85 a
Snapper	0 a	77 abcd	21 abc	98 bc	61 ab
1819	13 a	52 bcd	30 abc	95 bc	83 a
Intruder	12 a	63 abcd	17 bc	92 bc	83 a
1718	10 a	70 abcd	11 bc	90 bc	70 a
Declaration	13 a	39 cd	21 abc	74 bc	24 c
Karisma	10 a	46 bcd	6 c	62 c	56 ab
Alliance	6 a	39 cd	16 bc	60 c	34 bc
Paladin	0 a	33 cd	13 bc	46 c	87 a
Camelot	0 a	0 d	0 c	0 c	0 c

^z Number of extra-large (>0.5 lb) sized fruit, large (.33-.49 lb) sized fruit, and medium-sized (.25-.32 lb) boxes per acre.

^y Total number of marketable (extra-large, large, and medium) boxes (28 lb) per acre.

^x Percentage of harvested fruit with 'silvering'.

^v Fisher's Least Significant Difference (LSD) test ($P=0.05$)

Table 4. Number of 28-lb boxes per acre of extra-large, large-, and medium-sized fruit, total marketable boxes per acre, and percentage of marketable fruit with 'silvering' at harvest 4 on 14 Sep. at the Rutgers Agricultural Research and Extension Center in 2015.

Cultivar / BL	Number of boxes per acre ^z			Marketable boxes/A ^y	Marketable fruit with silvering (%) ^x
	Extra-large	Large	Medium		
Turnpike	74 a ^v	115 ab	25 abc	213 a	66 abc
9009	41 ab	148 a	21 abc	210 a	40 cd
Archemidis	36 ab	127 a	42 a	205 a	55 abcd
Aristotle X3R	36 ab	125 a	30 ab	191 a	71 abc
Revolution	31 ab	124 a	22 abc	176 a	46 bcd
1718	23 ab	104 ab	29 abc	155 ab	66 abc
Karisma	19 b	102 ab	22 abc	143 ab	74 abc
Snapper	34 ab	74 ab	20 abc	127 ab	65 abc
Alliance	38 ab	75 ab	12 bc	124 ab	21 de
1819	29 ab	69 ab	10 bc	107 ab	62 abc
Tomcat	30 ab	66 ab	10 bc	106 ab	83 ab
Paladin	24 ab	63 ab	15 abc	102 ab	87 a
Intruder	17 b	52 ab	31 ab	100 ab	68 abc
Declaration	24 ab	55 ab	7 bc	86 ab	64 abc
Camelot	0 b	5 b	0 c	5 b	0 e

^z Number of extra-large (>0.5 lb) sized fruit, large (.33-.49 lb) sized fruit, and medium-sized (.25-.32 lb) boxes per acre.

^y Total number of marketable (extra-large, large, and medium) boxes (28 lb) per acre.

^x Percentage of harvested fruit with 'silvering'.

^v Fisher's Least Significant Difference (LSD) test ($P=0.05$)

Table 5. Number of 28-lb boxes per acre of extra-large, large-, and medium-sized fruit, total marketable boxes per acre, and percentage of marketable fruit with 'silvering' at harvest 5 on 21 Sep. at the Rutgers Agricultural Research and Extension Center in 2015.

Cultivar / BL	Number of boxes per acre ^z			Marketable boxes/A ^y	Marketable fruit with silvering (%) ^x
	Extra-large	Large	Medium		
Archemidis	29 a ^y	112 a	47 a	187 a	58 abc
1718	8 abc	99 a	28 ab	135 ab	67 abc
Aristotle X3R	8 abc	94 a	18 bc	120 abc	48 abc
Revolution	15 abc	78 ab	21 abc	114 abc	30 bc
Alliance	25 abc	71 ab	12 bc	107 abc	55 abc
Tomcat	18 abc	72 ab	16 bc	107 abc	75 ab
Turnpike	32 a	61 ab	12 bc	105 abc	52 abc
Intruder	9 abc	82 ab	13 bc	104 abc	78 ab
9009	6 abc	69 ab	16 bc	92 abc	41 bc
1819	27 ab	54 ab	8 bc	89 abc	78 ab
Snapper	15 abc	68 ab	4 bc	87 abc	43 abc
Declaration	3 bc	63 ab	3 bc	69 abc	56 abc
Karisma	8 abc	43 ab	14 bc	66 bc	24 c
Paladin	8 abc	30 ab	10 bc	48 bc	93 a
Camelot	0 c	4 b	0 c	4 c	50 abc

^z Number of extra-large (>0.5 lb) sized fruit, large (.33-.49 lb) sized fruit, and medium-sized (.25-.32 lb) boxes per acre.

^y Total number of marketable (extra-large, large, and medium) boxes (28 lb) per acre.

^x Percentage of harvested fruit with 'silvering'.

^y Fisher's Least Significant Difference (LSD) test ($P=0.05$)

Table 6. Number of 28-lb boxes per acre of extra-large, large-, and medium-sized fruit, total marketable boxes per acre, and percentage of marketable fruit with 'silvering' at harvest 6 on 1 Oct. at the Rutgers Agricultural Research and Extension Center in 2015.

Cultivar / BL	Number of boxes per acre ^z			Marketable boxes/A ^y	Marketable fruit with silvering (%) ^x
	Extra-large	Large	Medium		
Archemidis	31 ab ^v	111 a	18 a	160 a	33 bcde
Turnpike	31 ab	106 a	20 a	156 a	43 abcd
Alliance	42 a	109 a	5 abc	156 a	29 cde
Revolution	26 ab	112 a	10 abc	148 a	19 de
9009	22 ab	101 a	17 a	140 a	34 bcde
Aristotle X3R	14 ab	89 a	9 abc	113 ab	23 de
1718	11 ab	71 ab	16 ab	98 ab	16 de
Intruder	12 ab	71 ab	5 abc	88 ab	61 abc
Declaration	26 ab	50 ab	11 abc	87 ab	8 e
Tomcat	9 b	57 ab	14 abc	81 ab	63 abc
Paladin	6 b	58 ab	6 abc	70 ab	72 a
1819	25 ab	44 ab	0 c	69 ab	64 ab
Snapper	19 ab	41 ab	2 bc	61 ab	6 e
Karisma	10 b	41 ab	8 abc	59 ab	13 de
Camelot	3 b	9 b	0 c	12 b	0 e

^z Number of extra-large (>0.5 lb) sized fruit, large (.33-.49 lb) sized fruit, and medium-sized (.25-.32 lb) boxes per acre.

^y Total number of marketable (extra-large, large, and medium) boxes (28 lb) per acre.

^x Percentage of harvested fruit with 'silvering'.

^v Fisher's Least Significant Difference (LSD) test ($P=0.05$)

Table 7. Number of 28-lb boxes per acre of extra-large, large-, and medium-sized fruit, total marketable boxes per acre, and percentage of marketable fruit with 'silvering' at harvest 7 on 14 Oct. at the Rutgers Agricultural Research and Extension Center in 2015.

Cultivar / BL	Number of boxes per acre ^z			Marketable boxes/A ^y	Marketable fruit with silvering (%) ^x
	Extra-large	Large	Medium		
Intruder	33 a	193 a ^v	55 a	281 a	59 a
Revolution	29 a	192 a	46 ab	267 ab	9 c
Archemidis	22 a	122 ab	54 a	198 abc	34 abc
Aristotle X3R	10 a	123 ab	49 ab	182 abc	28 abc
Declaration	22 a	103 ab	43 abc	168 abc	6 c
9009	12 a	110 ab	46 ab	168 abc	27 abc
Tomcat	20 a	91 bc	36 abc	147 abcd	41 abc
Paladin	15 a	78 bc	54 a	147 abcd	58 a
Snapper	13 a	111 ab	14 abc	139 abcd	30 abc
Turnpike	19 a	83 bc	27 abc	129 bcd	31 abc
Karisma	22 a	55 bc	28 abc	106 cd	15 bc
Alliance	24 a	52 bc	27 abc	104 cd	6 c
1718	13 a	56 bc	29 abc	98 cd	6 c
1819	12 a	49 bc	6 bc	66 cd	46 ab
Camelot	3 a	9 c	0 c	12 d	59 a

^z Number of extra-large (>0.5 lb) sized fruit, large (.33-.49 lb) sized fruit, and medium-sized (.25-.32 lb) boxes per acre.

^y Total number of marketable (extra-large, large, and medium) boxes (28 lb) per acre.

^x Percentage of harvested fruit with 'silvering'.

^v Fisher's Least Significant Difference (LSD) test ($P=0.05$)

Table 8. Total number of 28-lb boxes per acre of extra-large, large-, and medium-sized fruit, total marketable boxes per acre, and percentage of marketable fruit with 'silvering', and AUDPC values at the Rutgers Agricultural Research and Extension Center in 2015.

Cultivar / BL	Number of boxes per acre ^z			Marketable boxes/A ^y	Marketable fruit with silvering (%) ^x	AUDPC Value ^v
	Extra-large	Large	Medium			
Paladin	53 bc ^u	270 bc	105 abc	427 bc	72 a	3283 a-d
Tomcat	88 bc	399 abc	100 bc	586 abc	71 a	2300 a-d
Intruder	83 bc	471 ab	120 ab	674 ab	66 ab	1479 d
Turnpike	210 a	524 ab	99 bc	833 ab	65 ab	2503 a-d
1819	109 abc	274 bc	53 bc	437 bc	65 ab	4181 ab
Aristotle X3R	86 bc	568 ab	133 ab	787ab	51 ab	2247 bcd
Archemidis	151 ab	680 a	222 a	1053 a	51 ab	1958 cd
Karisma	70 bc	290 bc	78 bc	438 bc	50 ab	4370 a
Camelot	6 c	27 c	0 c	33 c	50 ab	3645 abc
9009	113 abc	626 ab	154 ab	893 ab	46 ab	2540 a-d
1718	96 bc	445 ab	119 abc	659 ab	44 ab	3592 a-d
Snapper	81 bc	405 abc	61 bc	547 abc	42 ab	3531 a-d
Alliance	151 ab	402 abc	81 bc	633 ab	41 ab	3168 a-d
Revolution	113 abc	646 ab	122 ab	881 ab	36 ab	2381 a-d
Declaration	125 ab	362 abc	89 bc	576 abc	34 b	3800 abc

^z Number of extra-large (>0.5 lb) sized fruit, large (.33-.49 lb) sized fruit, and medium-sized (.25-.32 lb) boxes per acre.

^y Total number of marketable (extra-large, large, and medium) boxes (28 lb) per acre.

^x Percentage of harvested fruit with 'silvering'.

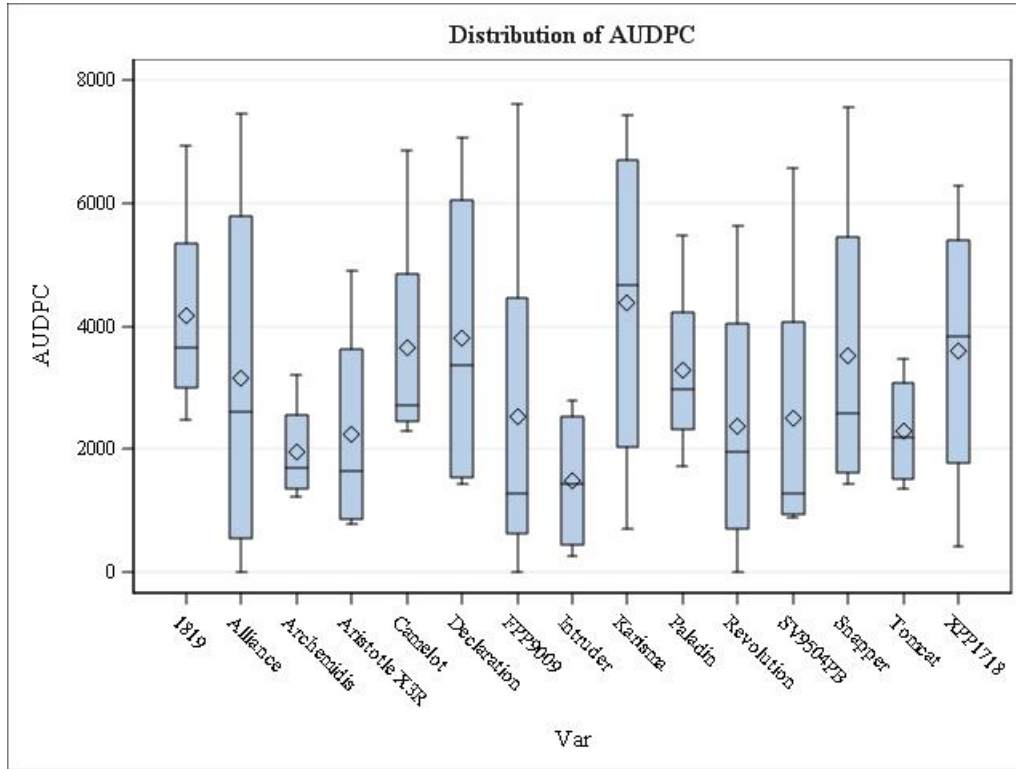
^v Area Under Disease Progress Curve value

^u Fisher's Least Significant Difference (LSD) test ($P=0.05$)

Table 9. Total percentage of pepper plants killed by *Phytophthora capsici* by week at the Rutgers Agricultural Research and Extension Center in Bridgeton, NJ in 2015.

VAR/BL	6/22	6/29	7/6	7/13	7/20	7/27	8/3	8/10	8/17	8/24	8/31	9/8	9/14	9/21	9/28	10/5	10/12
1819	0	1	1	1	4	26	43	47	54	56	57	58	58	57	69	69	75
Karisma	4	4	4	8	11	18	36	42	49	51	61	63	65	67	69	69	69
XPP1718	0	1	1	1	3	18	32	39	44	46	49	54	56	56	58	60	60
Camelot	0	0	1	3	7	17	31	35	40	47	47	50	50	49	51	56	58
Alliance	0	0	3	4	4	25	33	33	35	36	39	42	43	44	50	56	58
Paladin	0	1	1	1	4	15	25	33	39	42	44	46	46	47	51	56	56
Declaration	0	0	0	1	3	25	43	47	50	51	51	53	53	51	53	53	54
Tomcat	0	0	0	0	0	4	7	8	14	19	22	35	36	38	44	46	51
Snapper	3	1	3	15	17	24	31	32	38	39	40	42	42	44	46	46	49
FPP9009	1	0	0	1	7	26	25	25	25	28	28	32	33	33	35	40	43
Turnpike	1	1	1	1	1	8	19	22	25	26	31	33	35	36	38	39	42
Aristotle X3R	0	1	1	1	4	11	15	19	21	21	25	29	32	35	32	36	39
Revolution	1	1	1	1	1	13	22	26	26	31	31	26	32	33	35	38	38
Archemidis	1	1	1	1	1	3	8	11	15	15	15	21	22	22	25	26	36
Intruder	0	0	0	0	0	1	8	8	13	14	17	15	24	22	22	22	33

Figure 2. Boxplots for AUDPC values by cultivar/breeding line at the Rutgers Agricultural Research and Extension Center in Bridgeton, NJ in 2015.



Boxplot where top whisker = maximum AUDPC Value; bottom whisker = minimum AUDPC Value; line in box = median AUDPC Value; diamond in box = mean AUDPC Value.

SV9504PB = Turnpike