

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, 2014.

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 30 May, 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 11 Jul; 6, 20, and 27 Aug; 10 and 24 Sep; and 1 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 2.23, 2.10, 9.51, and 3.06 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 1-9). Overall, Archimedes produced the highest yield at 866 total boxes of fruit per acre followed by Paladin (777), Declaration (700), Revolution (687), 1819 (686), and Intruder (607) (Table 9). Snapper produced the lowest yield at 189 total boxes/acre (Table 8). Declaration, Intruder, and Archimedes produced the highest number of extra-large boxes per acre at 119 and 117, respectively (Table 8). Archimedes, Paladin, 1819, and Declaration produced the highest number of large-sized fruit boxes per acre (Table 8). Intruder, E-209, E-032, and Paladin produced the highest number of medium-sized fruit boxes per acre (Table 8). Total percentage of harvested fruit with silvering ranged from 0 to 43% depending on cultivar or breeding line (Table 8). Silvering was lowest in *Phytophthora*-susceptible Camelot (0%) and highest in *Phytophthora*-resistant Paladin (43%) (Table 8).

The total percentages of plants killed by *P. capsici* by week were calculated for each cultivar/breeding line and ranged from 21 to 89% (Tables 8 and 9; Fig. 1). Cultivars and breeding lines with the fewest plants killed by *P. capsici* during the production season included Intruder (13%), JPR1107 (21%), and Archimedes (29%) (Table 9; Fig. 1). Plant death was highest in the *Phytophthora*-susceptible cultivars Camelot (73%), Karisma (88%), and Alliance (89%) (Table 9). Importantly, plant death caused by *P. capsici* was considered extremely high in *Phytophthora*-resistant lines Aristotle (70%) and Paladin (41%) which generally perform much better in this annual trial 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 and 9). AUDPC values were lowest in JPR1107 (857) and Intruder (770) (Table 8).

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 11 Jul at the Rutgers Agricultural Research and Extension Center in 2014.

Cultivar / BL	Number of boxes per acre ^z			Marketable boxes/A ^y	Marketable fruit with silvering (%) ^x
	Extra-large	Large	Medium		
FPP9006	0c ^v	17efg	2b	22fg	85a
Paladin	0c	36b-f	15ab	51c-g	50b
E.20B.30032	0c	19efg	6ab	25fg	47b
E.20B.SI209	3c	27d-g	5ab	35e-g	44bc
Karisma	0c	20efg	14ab	34e-g	34bcd
Intruder	0c	29c-f	5ab	34e-g	30b-e
Archimedes	0c	66b	12ab	78b-e	28b-e
FPP1718	9c	40b-e	14ab	63b-f	23b-e
Aristotle	33c	45b-e	22a	101abc	20b-e
Tomcat	14c	27d-g	3ab	44d-g	20b-e
Snapper	3c	15efg	8ab	26gf	13cde
1819	16bc	121a	13ab	151a	9de
RPP31123	16bc	30c-g	3ab	49d-g	6de
Declaration	42a	51bcd	14ab	108ab	4de
Alliance	12c	58bc	20ab	91bcd	3de
Camelot	0c	6fg	4ab	44d-g	0e
Revolution	19bc	45b-e	2b	65b-f	0e
JPR1107	0c	2g	3ab	5g	0e

^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 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 6 Aug at the Rutgers Agricultural Research and Extension Center in 2014.

Cultivar / BL	Number of boxes per acre ^z			Marketable boxes/A ^y	Marketable fruit with silvering (%) ^x
	Extra-large	Large	Medium		
Paladin	0a ^v	80abc	29ab	109abc	53
E.20B.SI209	0a	54bc	13bc	67bc	40
Archimedes	0a	110ab	38a	148ab	37
Tomcat	0a	28bc	18abc	45bc	33
FPP9006	0a	21bc	8bc	8bc	30
Aristotle	6a	91abc	29ab	126abc	30
E.20B.30032	0a	52bc	6bc	59bc	27
FPP1718	0a	80abc	14bc	94abc	24
1819	0	88abc	8bc	96abc	16
Declaration	0a	80abc	9bc	98abc	15
Intruder	3a	59abc	0c	62bc	14
Karisma	0a	46bc	8bc	54bc	11
Snapper	0a	46bc	5c	50bc	11
RPP31123	3a	97abc	5c	105abc	10
Revolution	9a	151a	21abc	181a	5
JPR1107	0a	10c	16abc	26c	5
Alliance	11a	72abc	20abc	103abc	0
Camelot	3a	36bc	11bc	50bc	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'.

^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 20 Aug at the Rutgers Agricultural Research and Extension Center in 2014.

Cultivar / BL	Number of boxes per acre			Marketable boxes/A	Marketable fruit with silvering (%)
	Extra-large	Large	Medium		
Paladin	11d	191a	13c	215ab	50a
Tomcat	17cd	112a-d	14c	143a-e	36b
Archimedes	65ab	151a	15c	230ab	28bc
Intruder	80a	152ab	11c	244a	23cd
1819	17cd	130abc	20bc	167a-d	18cde
Snapper	20cd	33de	0c	53de	14def
RPP31123	19cd	59cde	8c	86cde	11efg
Aristotle	16cd	100b-e	5c	121b-e	10efg
FPP1718	19cd	109a-d	15c	121b-e	9efg
FPP9006	6d	27de	15c	49de	8efg
Revolution	28bcd	101b-e	6c	135a-e	5fg
Karisma	32bcd	111a-d	7c	149a-d	3fg
E.20B.30032	20cd	138abc	55a	213ab	3fg
Camelot	8d	87b-e	16c	112b-e	0g
E.20B.SI209	5d	14c	32c	3c	0g
JPR1107	0d	35de	43ab	43ab	0g
Alliance	14cd	62cde	7c	7c	0g
Declaration	51abc	138abc	12c	12c	0g

^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 27 Aug at the Rutgers Agricultural Research and Extension Center in 2014.

Cultivar / BL	Number of boxes per acre			Marketable boxes/A	Marketable fruit with silvering (%)
	Extra-large	Large	Medium		
Aristotle	0d	42a-d	23a-e	76abc	49a
Tomcat	5b	73abc	34a-d	112ab	30ab
Paladin	6b	59a-d	26a-e	92abc	27bcd
FPP1718	0b	57a-d	21a-e	81abc	12bcd
Archimedes	21ab	82ab	37ab	141a	11bcd
1819	0b	19bcd	27a-e	43bc	10bcd
Intruder	5b	23a-d	6b-e	34bc	8cd
FPP9006	3b	21bcd	12b-e	36bc	6d
JPR1107	0b	50a-d	35abc	85abc	1d
Karisma	0b	46cd	17a-e	64abc	0d
Camelot	0b	17bcd	6b-e	23bc	0d
Revolution	21ab	88a	37ab	146a	0d
E.20B.SI209	0b	11cd	2de	13c	0d
E.20B.30032	0b	41a-d	46a	87abc	0d
RPP31123	9ab	6d	3cde	18bc	0d
Alliance	32a	47a-d	14b-e	43abc	0d
Declaration	0b	54a-d	11b-e	65abc	0d
Snapper	0b	0d	0e	0c	0d

^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 10 Sep at the Rutgers Agricultural Research and Extension Center in 2014.

Cultivar / BL	Number of boxes per acre			Marketable boxes/A	Marketable fruit with silvering (%)
	Extra-large	Large	Medium		
Aristotle	3c	40a-e	15bcd	58a-e	44a
RPP31123	9a	49a-d	8bcd	65a-e	44a
1819	0a	61ab	35abc	96ab	41a
E.20B.SI209	5a	10de	5cd	20cde	40a
Paladin	9a	55abc	21a-d	85abc	35ab
Karisma	5a	25b-e	3d	33b-e	26abc
Intruder	5a	38a-e	8bcd	51a-e	19abc
FPP9006	6a	22b-e	7bcd	35b-e	18abc
E.20B.30032	0a	23b-e	12bcd	36b-e	18abc
Archimedes	8a	57abc	23a-d	88ab	12abc
FPP1718	3a	59ab	15bcd	77a-d	6bc
Tomcat	5e	48a-d	8bcd	61a-e	5bc
JPR1107	3a	25b-e	49a	77a-d	4bc
Declaration	8a	67a	38ab	114a	4bc
Camelot	5a	39a-e	24a-d	69a-c	0c
Revolution	5a	24b-e	6cd	36b-e	0c
Alliance	0a	17cde	2d	18de	0c
Snapper	0a	0a	4cd	4e	0c

^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 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 24 Sep at the Rutgers Agricultural Research and Extension Center in 2014.

Cultivar / BL	Number of boxes per acre			Marketable boxes/A	Marketable fruit with silvering (%)
	Extra-large	Large	Medium		
FPP9006	3ab	12bc	9ab	23b-f	46a
RPP31123	3ab	18bc	5b	25b-f	46a
Intruder	17a	28abc	24a	69ab	38a
Alliance	0b	7c	5b	12ef	33a
E.20B.30032	3ab	12bc	12ab	27b-f	28a
E.20B.SI209	5ab	11bc	2b	18def	25a
1819	15a	37abc	10ab	62a-d	24
FPP1718	3ab	45ab	11ab	58a-e	24a
Archimedes	11ab	59a	7ab	77a	22a
Revolution	0b	24bc	3b	27b-f	22a
Paladin	15a	59a	15ab	87a	18a
Tomcat	3ab	59a	6b	67abc	13a
JPR1107	0b	31abc	19ab	50a-f	7a
Declaration	3ab	32abc	10ab	45a-f	3a
Karisma	0b	5c	15ab	20c-f	0a
Aristotle	0b	17bc	5b	22b-f	0a
Camelot	0b	29abc	14ab	43a-f	0a
Snapper	0b	4c	2b	6f	0a

^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 1 Oct at the Rutgers Agricultural Research and Extension Center in 2014.

Cultivar / BL	Number of boxes per acre			Marketable boxes/A	Marketable fruit with silvering (%)
	Extra-large	Large	Medium		
FPP9006	11ab	9bcd	4ef	25cde	75a
Paladin	22a	78a	38a-d	139c	56ab
RPP31123	6ab	41a-d	143c-f	61a-e	53ab
Declaration	6ab	45a-d	18c-f	69a-c	51ab
Revolution	3b	41a-d	54a	98abc	43abc
Archimedes	11ab	58ab	34a-e	103abc	35a-d
Tomcat	5ab	29cd	44abc	79a-e	31cde
E.20B.30032	3b	37a-d	19c-f	59a-e	29bcd
Intruder	9ab	53abc	51ab	112ab	23bcd
Alliance	0b	8bcd	10def	17de	21bcd
E.20B.SI209	3b	26bcd	16c-f	46b-e	19bcd
1819	3b	49a-d	20c-e	71a-e	17bcd
Aristotle	8ab	36a-d	22b-e	66a-e	15bcd
FPP1718	12ab	45a-d	35a-e	91a-d	14bcd
JPR1107	0b	23bcd	21b-e	44b-e	2cd
Karisma	0b	2cd	3f	5e	0d
Camelot	0b	20bcd	13def	33b-e	0d
Snapper	0b	0d	0f	0e	0d

^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 2014.

Cultivar / BL	Number of boxes per acre			Marketable boxes/A	Marketable fruit with silvering (%)	Total % plants killed	AUDPC Value
	Extra-large	Large	Medium			by Phytophthora	
Archimedes	117a	583a	166ab	866a	26bc	29	2074bc
Paladin	62a-e	557ab	157abc	777ab	43a	41	2041bc
Declaration	119a	468a-e	114a-d	700abc	7e-h	53	3157abc
Revolution	85ab	473a-d	129a-d	687a-d	6e-h	44	2747abc
1819	52b-e	505abc	126a-d	686a-d	14de	63	3154abc
Intruder	119a	383a-f	185a-d	607a-e	25bc	13	770c
FPP1718	48b-e	434a-e	123a-d	605a-e	13def	38	2408abc
Aristotle	78abc	370a-f	122a-d	570a-e	27bc	70	3805ab
Tomcat	50b-e	376a-f	126a-d	552a-e	21cd	65	3466ab
E.20B.30032	25b-e	370a-f	157abc	505b-f	12d-g	48	2383bc
Alliance	69a-d	270a-f	78cde	417c-e	2gh	89	5089a
RPP31123	65a-d	299c-f	46de	409c-g	22cd	53	2242bc
JPR1107	3c	174fg	185a	362d-g	3fgh	21	857c
Karisma	37b-e	255d-g	67de	359d-f	10e-h	88	4410ab
Camelot	17de	234efg	89b-e	339fg	0h	73	5046a
E.20B.SI209	22cde	155fg	157abc	222fg	32b	50	2540abc
FPP9006	31b-e	129g	59de	217fg	34ab	54	3242abc
Snapper	22cde	98g	18c	139g	12d-g	50	2283bc

^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 (AUDPC) values for the percentage of plants killed by *P. capsici*.

^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 2014.

CV/BL	6/6	6/13	6/19	6/26	7/3	7/11	7/17	7/25	7/31	8/7	8/14	8/21	8/28	9/5	9/12	9/18	9/26	10/2	10/8
Karisma	0	0	0	2	8	15	17	19	23	28	30	43	47	66	73	77	83	85	88
Archemidis	0	0	4	4	4	7	9	9	14	18	18	20	20	21	24	26	26	28	29
Aristotle	0	0	0	3	9	12	14	19	22	27	30	39	42	49	55	55	60	62	70
Camelot	0	0	1	4	4	22	39	45	46	50	53	56	56	60	64	66	70	72	73
Tomcat	0	0	0	3	3	13	19	21	22	26	31	33	39	39	48	53	59	61	65
Revolution	0	0	0	0	0	8	13	13	17	20	22	27	28	30	41	41	43	44	44
1819	0	0	0	3	3	6	14	15	24	25	29	35	39	43	49	53	58	61	63
Paladin	0	0	1	1	3	4	4	11	9	13	17	22	24	27	31	34	37	41	41
FPP9006	0	0	0	0	4	14	25	25	25	25	32	39	43	43	47	51	51	51	54
FPP1718	0	0	0	2	2	4	15	17	17	17	25	27	29	31	33	33	35	35	38
E.20B.SI209	0	0	0	0	0	0	0	5	5	10	30	45	45	45	45	50	50	50	50
E.20B.30032	0	0	0	0	0	3	7	16	18	18	19	25	25	28	32	34	41	44	48
RPP31123	0	0	3	3	3	6	6	12	15	15	18	24	26	26	29	29	34	38	53
Intruder	0	0	0	0	0	4	4	4	4	4	4	4	6	6	8	8	9	9	13
JPR1107	0	0	0	0	0	0	0	0	0	4	4	4	4	8	17	21	21	21	21
Alliance	0	0	0	7	12	23	28	34	38	53	56	61	63	66	72	72	81	86	89
Declaration	0	0	0	0	0	7	11	12	18	26	28	32	33	35	40	45	50	53	53
Snapper	0	0	3	3	3	3	3	3	3	3	11	28	31	45	45	45	45	50	50

Figure 1. Disease progress curves for cultivars and breeding lines evaluated for resistance to the crown rot phase of Phytophthora blight at the Rutgers Agricultural Research and Extension Center in Bridgeton, NJ in 2014.

