

University of Kentucky College of Agriculture  
New Crop Opportunities Center

## **Yield and Powdery Mildew Resistance of Fall-harvested Summer Squash**

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### **Introduction**

Although squash from late summer plantings often achieve the highest market prices, fungal and virus diseases frequently cause serious damage in fall-harvested squash and are considered important barriers to profitable production in Kentucky and surrounding states.

It was our intention to evaluate varieties and breeding lines for yield and virus resistance in a fall-harvested trial. Because there was a near absence of virus diseases this year, varieties and breeding lines were evaluated for marketable yield, powdery mildew (PM) resistance, and fruit appearance.

### **Materials and methods**

Thirty-four summer squash varieties or advanced breeding lines (sixteen zucchini, nine yellow straightneck, and nine yellow semi-crookneck or crookneck entries) were evaluated at the University of Kentucky Horticultural Research Farm in Lexington in the late summer and fall of 2002. These included several of the best performing varieties from the 1997 trial. Most cultural practices were according to our current commercial recommendations for Kentucky. Seeds were sown in the greenhouse on 18 July in 72-cell plastic trays and transplanted to the field on 6 Aug. Each plot consisted of eight plants spaced 18 inches apart in a single row on 6-inch high raised beds with white-on-black plastic mulch and drip irrigation. Beds were 6 ft apart from center to center. All 34 entries were planted together in a randomized complete block design with four replications. Varieties of each type (zucchinis, yellow straightneck or yellow crookneck) were grouped together within each block. Blocks consisted of two long rows with 16 or 17 entries per row. Single rows of the disease-susceptible variety Dixie were planted on both sides of each block to enhance natural disease buildup and uniform spread throughout the trial.

Sixty-five lbs N/acre were applied prior to planting while an additional 18 lbs N/acre was applied in three fertigations for a season total of 83 lbs N/acre. All P and K were applied preplant according to recommendations based on soil tests. Quadris was applied on Aug 7, 14, and 30 for fungal disease control; a tank mix of Nova and Bravo was applied on Sept 9 and 26. The systemic insecticide Admire was applied two days after transplanting as a post-transplant drench for cucumber beetle control. Two subsequent applications of Pounce were made for later season cucumber beetle and squash vine borer control.

Plots were harvested 3 days per week (MWF) from 27 Aug. until 4 Oct. for a total of 16 harvests. Fruits were counted and weighed after grading into either marketable fruit or culls. Marketable yield was expressed in terms of the number of half-bushel boxes per acre by dividing the total weight of marketable fruit per acre by 21 lbs. Following an analysis of variance, average yields and disease ratings were compared using Waller-Duncan's K-ratio T-test ( $P = 0.05$ ).

**Fruit quality ratings.** All fruits of each trial entry harvested from all four replications were graded and laid out on tables for careful examination and quality rating on 11 and 20 Sept. Fruits were

assessed for type, color, and overall appearance. Yellow squash type (straightneck, semi-crookneck, or crookneck) was determined based on our own observations rather than seed company descriptions. Yellow squash color was rated on a 1 to 5 scale with 1 = pale yellow with greenish tint and 5 = bright golden yellow. Zucchini squash color was scored from 1 = light green to 5 = very dark green, nearly black. Appearance was rated on a 1 to 9 scale with 1 = worst and 9 = best taking into account, in order of importance: overall attractiveness, shape, uniformity of shape, and color.

**Disease assessments.** Plants were visually assessed for the extent of PM symptoms on leaves (both upper and lower surfaces) and stems on 11 Sept. and 7 Oct. Although we did not identify PM species in this trial, mixtures of *Sphaerotheca fuliginea* and *Erysiphe cichoracearum* are usually found in late summer squash plantings; both species were identified in the 1997 trial.

## Results and Discussion

This harvest season was exceptional in that only a few of the over 2000 plants in the trial field showed any virus symptoms or yielded unmarketable fruits having virus symptoms. This was in spite of the presence of other cucurbit trials, which were planted earlier at the same location, and in spite of the extensive planting of a susceptible variety within the trial field. Commercial squash growers in central and western Kentucky also reported very low virus incidence in 2002. Mid-summer drought led to a decline in clover and other host plants and this may have resulted in the low virus incidence.

**Yellow straightnecks.** As was the case in 1997, conventionally-bred hybrids having the precocious yellow gene were in the highest yielding group of yellow straightneck squash varieties: Sunray, Multipik, Fortune, and Monet were not significantly different from the highest yielding Precious II (Table 1). Multipik and Fortune were also in this highest yielding group in 1997 when virus incidence was high. While lower yielding, Cougar and Seneca Supreme had the best fruit appearance scores among straightnecks (Table 1).

Powdery mildew symptoms were first observed inside leaf canopies of some varieties in mid-September. Sunray exhibited exceptional PM resistance while Precious II also had PM resistance that was significantly better than the resistance of other varieties in this group; Fortune and Multipik appeared to be the most susceptible to PM among the straightnecks tested (Table 1). In the absence of virus diseases, transgenic varieties Conqueror III and Liberator III were the lowest yielding in the group and were susceptible to PM; these varieties also had the lowest appearance scores (Table 1). Transgenics were among the highest yielders in 1997 when virus pressure was very high.

**Yellow crooknecks.** While transgenic varieties Prelude II and Destiny III were clearly superior among yellow crookneck entries in 1997 under intense virus pressure, only Prelude II was among the highest yielding crookneck varieties in 2002. Conventionally bred varieties Sunglo and Gentry were also not significantly different in yields from the highest yielding Medallion among crooknecks (Table 1). Both Sunglo and Prelude II showed an exceptional degree of PM resistance while the other varieties in this group were much more susceptible (Table 1). Lower-yielding Destiny III and Pic-N-Pic had the best appearance scores while appearance scores for the other varieties in this group were deemed acceptable.

**Zucchini.** One transgenic and six conventionally-bred zucchini varieties were in the highest yielding group that were not significantly different from highest yielding line HMX 0710; these included

Zucchini Elite, SVT 04620327 (transgenic virus resistance), Cashflow, Lynx, Dividend, Spineless Beauty, and Sunseeds 9523 (Table 1). Dividend was also in the highest yielding group in 1997. As in 1997, the transgenic virus-resistant Independence II was among the lowest yielding zucchini varieties. Appearance ratings were highest for HMX 0710, Cashflow, Sunseeds 9523, and Tigress; fruit from a single observation plot of Tigress also had high appearance ratings in 1997. Plots of both Tigress and Senator, however, had a single plant (of the 32 plants of each variety that were grown for the trial) that yielded off-type fruits. Zucchini Elite, Dividend, Senator, and ACX 34 also had good appearance ratings (Table 1); Zucchini Elite, Dividend, and Senator had high scores in the 1997 trial.

PM resistance was exceptionally high in breeding lines HMX 0710 (no symptoms) and SVT 04620327; Tigress also appeared to be resistant or tolerant to PM. PM ratings were significantly lower for HMX 0710, SVT 04620327, and Tigress than for the other zucchini varieties. Neither of the two numbered breeding lines had been named/released at the time of this writing.

Results from the 1997 fall-harvested trial at this location together with those from similar trials in other states demonstrated that transgenic virus-resistant squash varieties could provide excellent resistance to two or more of the viruses involved in mixed infections in the southeastern United States. Transgenic zucchini line SVT 04620327 and transgenic crookneck Prelude II both have high levels of PM resistance and performed very well in this trial; the other transgenic varieties did not perform as well in 2002 in the absence of significant virus pressure and under epidemic powdery mildew conditions.

Marketable yields in late plantings can be expected to vary considerably among varieties from year to year and location to location depending on the resistance package in the variety, diseases present in the field, and the growth stage at which the crop becomes infected. Precocious yellow straightneck varieties remain an excellent choice for high yields and masking of green fruit symptoms associated with moderate epidemics of WMV and CMV. New straightneck varieties Precious II, Sunray, Monet, and Cougar are recommended for small-scale trial by growers; Sunray and Precious II should provide valuable levels of PM resistance. Fortune and Multipik will remain on our list of suggested varieties for Kentucky growers in spite of their susceptibility to PM. While lower yielding in this trial, transgenic virus resistant varieties should perform considerably better in most late summer plantings when virus diseases are serious risks for growers.

New crookneck varieties Medallion and Sunglo are recommended for grower trial. Prelude II will remain the only transgenic crookneck on our list of suggested varieties. New standouts among zucchinis recommended for grower trial are HMX 0710 (not yet released) for its high yields of attractive fruits and exceptional PM resistance. Cashflow, SVT 04620327 (not yet released), Lynx, and Sunseeds 9523 are also recommended for growers' trials. High levels of PM resistance are now available in varieties of all three types of summer squash grown in Kentucky. PM resistance should be considered together with virus resistance, fruit appearance and other horticultural characteristics in selecting varieties for late summer production.

Table 1. Yields and powdery mildew assessments for yellow straightneck, crookneck, and zucchini squash varieties, breeding lines; data are means of four replications; appearance ratings are averages from two assessments of all fruits harvested from four replications.

Entry	Source	Type <sup>z</sup>	Mkt. Yield boxes/acre <sup>y</sup>	Powdery mildew <sup>x</sup>			Appear rating <sup>w</sup>
				11 Sept.	7 Oct.	Avg.	
<b>I. Yellow straightneck and slight semi-crookneck:</b>							
Precious II	AC	SN-Py	1660	1.8	0.7	1.2	5.5
Sunray	SM	SN/sCN-Py	1536	0.1	0.4	0.3	6.5
Multipik	HM	SN-Py	1526	3.0	3.7	3.4	6.5
Fortune	RG	SN-Py	1513	3.7	3.2	3.5	6.5
Monet	HM	SN-Py	1511	2.5	3.5	3	6.5
Goldbar	SM	SN	1475	2.5	2.7	2.6	5.5
Cougar	HM	SN/sCN-Py	1369	2.6	2.7	2.7	7.0
Seneca Supreme	SM	SN-Py	1327	2.6	2.7	2.7	7.0
Lioness	HM	SN	1281	2.7	1.0	1.9	5.0
Conqueror III	SM	SN,Tg-3+	1262	2.6	2.5	2.6	4.5
Liberator III	SM	SN,Tg-3	1219	3.0	3.2	3.1	4.0
<b>II. Yellow semi-crookneck or crookneck:</b>							
Medallion	AC	sCN/CN	1663	3.2	3.0	3.1	5.5
Sunglo	RG	sCN/CN	1495	0.2	0.5	0.4	5.5
Prelude II	SM	CN	1462	0.0	0.1	0.1	5.5
Gentry	RG	sCN	1450	2.6	3.5	3.1	5.5
Dixie	SM	CN	1384	3.9	3.5	3.7	5.5
Destiny III	SM	sCN/CN,Tg-3	1267	3.5	3.5	3.5	6.0
Pic-n-Pic	SW	CN	1101	3.7	3.7	3.7	6.0
<i>Waller-Duncan LSD (all yellow squash, P=.05).</i>			220	0.6	0.7	0.6	---
<b>III. Zucchini:</b>							
HMX 710	HM	Z	1722	0.0	0.0	0.0	7.0
Zucchini Elite	HM	Z	1694	3.3	2.3	2.8	6.0
SVT 4620327	SM	Z, Tg-3	1686	0.4	0.0	0.2	5.5
Cashflow	RG	Z	1635	4.2	4.2	4.2	6.5
Lynx	HM	Z	1567	4.0	2.7	3.4	5.0
Dividend	RG	Z	1517	3.5	3.0	3.2	6.0
Spineless Beauty	RG	Z	1466	4.0	3.0	3.5	5.5
9523	SS	Z	1445	4.3	4.3	4.3	6.5
Revenue	RG	Z	1276	3.5	3.5	3.5	5.5
Robuster	SS	Z	1262	4.0	4.4	4.2	5.5
Senator	SM	Z	1215	3.2	2.2	2.7	6.0
AXC 34	AC	Z	1207	4.7	3.5	4.1	6.0
Tigress	HM	Z	1172	2.0	1.7	1.8	6.5
Independence II	SM	Z,Tg-2	1146	4.0	2.5	3.2	5.0
Seasons	AC	Z	1130	4.5	4.0	4.2	5.0
ACX 45	AC	Z	1123	5.0	4.2	4.6	5.5
<i>Waller-Duncan LSD (zucchini, P=.05)</i>			326	0.6	1.3	0.7	--

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<sup>z</sup>All entries from conventional breeding programs except for: Tg = transgenic for resistance to two (Tg-2) or three (Tg-3) viruses; Tg-3+ = transgenic for three viruses with resistance to the fourth (PRSV) obtained through conventional breeding. Type descriptions based on our observations on 11 and 20 Sept.: SN = straightneck, CN = crookneck, sCN = semi-crookneck; some varieties that we considered semi-crookneck are considered straightneck by the seed company and are included in the straightneck grouping; Py = has precocious yellow gene to mask virus symptoms.

<sup>y</sup>Number of half-bushel (21lb = 9.52 kg) boxes per acre.

<sup>x</sup>Visual rating scale from 0 = no symptoms to 5 = extensive symptoms on entire plants; ratings took into account the percentage of upper and lower leaf and stem surfaces that were covered by powdery mildew symptoms; assessed by W. Nesmith on 11 Sept and 7 Oct (3 days after final harvest).

<sup>w</sup>Appearance ratings where 1 = worst, 9 = best taking into account, in order of importance, overall attractiveness, shape, and color.

Table 2. Fruit color, appearance and other observations for yellow straightneck, crookneck, and zucchini squash varieties and breeding lines; ratings are averages from two assessments (11 and 20 Sept, 2002); all fruits bulked from four replications at each of the two harvests.

Entry	Type <sup>z</sup>	Color <sup>y</sup>	Appear. rating <sup>x</sup>	Shape/comments/suitability
Precious II	SN-Py	2.7	5.5	Very long with long, thick neck; pale yellow w/ greenish tint at blossom end; 50% curved.
Sunray	SN/sCN-PY	3.0	6.5	Elongated teardrop shape; very slight crook; good color.
Multipik	SN-Py	3.2	6.5	Long teardrop shape.
Fortune	SN-Py	3.0	6.5	Medium long teardrop shape; 20% curved.
Monet	SN-Py	3.5	6.5	Teardrop shape; nice color.
Goldbar	SN	2.0	5.5	Long w/ very slight crook in most; greenish cast.
Cougar	SN/sCN-Py	3.0	7.0	Long teardrop shape; slight crook.
Seneca Supreme	SN-Py	3.0	7.0	Teardrop shape; attractive.
Lioness	SN	1.5	5.0	Long w/ slight crooks; greenish cast in smallest fruits.
Conqueror III	SN	1.5	4.5	Very long, thin; 50% slightly curved; greenish cast.
Liberator III	SN	1.5	4.0	Very long, thin; 50% slightly curved; greenish cast.
Medallion	sCN/CN	3.5	5.5	Good color; medium thick neck.
Sunglo	sCN/CN	2.0	5.5	Medium thick neck; pale w/ greenish cast.
Prelude II	CN	2.0	5.5	Medium thick neck; greenish cast.
Gentry	sCN	3.5	5.5	Medium thick neck; shape somewhat variable.
Dixie	CN	2.0	5.5	Thick neck; greenish cast.
Destiny III	sCN/CN	2.0	6.0	Medium thick neck; greenish cast.
Pic-N-Pic	CN	2.7	6.0	Thinner neck than most; greenish cast in smallest fruits
HMX 0710	Z	3.0	7.0	Medium dark green; 50% w/ slight curve and very slight taper (almost cylindrical).
Zucchini Elite	Z	3.0	6.0	Medium green; 50% w/ slight curve; larger diam. Blossom end (slight taper).
SVT 04620327	Z	3.7	5.5	Medium dark green; 50% w/ slight curve; many with slight and occasionally uneven taper.
Cashflow	Z	3.0	6.5	Medium green; 40% w/ slight curve; very slight taper.
Lynx	Z	3.7	5.0	Medium green; 60% w/ slight to moderate curve; slight taper.
Dividend	Z	3.0	6.0	Light to medium green; 20% w/ slight curve; slight taper, nearly perfectly cylindrical; very nice looking.
Spineless Beauty	Z	3.7	5.5	Medium dark green; angular fruit; mostly slightly curved and tapered (larger blossom end).
9523	Z	4.0	6.5	Medium dark green; most slightly curved; strong taper (larger blossom end); attractive glossy color.
Revenue	Z	3.0	5.5	Light to medium green; slightly larger blossom end; most slightly curved.
Robuster	Z	3.0	5.5	Medium green; 20% curved w/ very slight taper.
Senator	Z	2.5	6.0	Light to medium green; heavily speckled; most slightly curved with smooth taper; one plant with off-type fruits in this trial.

AXC 34	Z	3.0	6.0	Light to medium green; mostly slightly curved w/ very slight taper.
Tigress	Z	2.0	6.5	Gray-green speckled; 50% slightly curved; tapered; one plant with off-type fruits in this trial.
Independence II	Z	2.7	5.0	Medium green; most fruits slightly curved and tapered.
Seasons	Z	4.2	5.0	Medium dark green; 40-50% slightly curved, straight to very slight taper; shape not uniform.
ACX 45	Z	4.7	5.5	Very dark green; most slightly curved; no taper.

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<sup>z</sup>Type descriptions based on our observations on 11 and 20 Sept. (SN = straightneck, SN-Py = straightneck with precocious yellow gene, CN = crookneck, sCN = semi-crookneck); some varieties that we considered semi-crookneck may be considered straightneck by the seed company.

<sup>y</sup>Color ratings for yellow squash: 1 = pale yellow with greenish tint; 5 = bright golden yellow; for zucchini, 1 = lightest green; 5 = nearly black.

<sup>x</sup>Appearance ratings: 1 = worst; 9 = best taking into account, in order of importance, overall attractiveness, shape, and color.