Yield and Powdery Mildew Resistance of Fall-Harvested Summer Squash

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Introduction

Fungal and virus diseases are primary concerns in successfully producing and marketing a fall summer squash crop in Kentucky. Under certain conditions, virus can render a squash crop unmarketable by discoloring fruit and affecting plant growth. Infections of more than one virus commonly occur in fall-harvested summer squash in Kentucky. Watermelon mosaic virus (WMV, formerly WMV-2), zucchini yellow mosaic virus (ZYMV), squash mosaic virus (SqMV), cucumber mosaic virus (CMV) and papaya ringspot virus (PRSV, formerly WMV-1) have all occurred in Kentucky at one time or another and in most other southeastern states.

Many straight neck yellow squash have the precocious yellow (Py) gene that masks the greening effect in summer squash fruits produced on plants infected by CMV or WMV. Unfortunately, precocious yellow summer squash will show the greening effect when PRSV or ZYMV is present. Transgenic squash resistant to PRSV and ZYMV (TG-3+) are supposed to be resistant to all four viruses.

This trial was planned to evaluate thirty-four squash cultivars in response to virus pressure in a fall planting. The low occurrence of virus disease in this year's trial allowed only one rating of virus damage. The cultivars were evaluated for powdery mildew (PM) resistance, yield and appearance.

Materials and Methods

Thirty-four summer squash cultivars or advanced breeding lines (fifteen zucchini, eleven straight neck summer squash and eight crook or semi-crook neck) were evaluated at the University of Kentucky Horticultural Research Farm in Lexington in the late summer and fall of 2003. These included some of the best performing cultivars from the 2002 trial. Most cultural practices were according to current commercial recommendations for Kentucky. Seeds were sown in the greenhouse on 16 July in 72-cell plastic trays and transplanted to the field on 11 August. Each plot consisted of eight plants spaced 18 inches apart in a single row on 6-inch high raised beds with black plastic mulch and drip irrigation. Beds were 8 ft apart from center to center. All 34 entries were planted together in a randomized complete block design with four replications. Cultivars of each type (zucchinis, yellow straightneck or yellow crookneck) were grouped together within each block. Blocks consisted of two long rows with 17 entries per row. Single rows of the disease-susceptible cultivar Dixie were planted on both sides of each block to enhance natural disease buildup and uniform spread throughout the trial.

One hundred lbs N/acre were applied prior to planting while an additional 27 lbs N/acre were applied in four applications for a total of 128 lbs N/acre. All P and K were applied preplant according to soil test recommendations. When cucumber beetle populations were high, Pounce was applied, and for disease control, Bravo and Nova were applied. The pre-emergent herbicide Curbit was applied between rows for weed control.

Plots were harvested three days a week (MWF) from 29 August to 1 October for a total of 13 harvests. A hard frost on 3 October damaged plants, preventing further harvests. After harvesting, fruits were counted and weighed after grading into either marketable fruit or culls. Marketable yield is expressed as 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 15 September. Both the yellow squash and the zucchini squash color were evaluated for uniformity with a score of 1 = highly variable to 5 = uniform, and scores were lowered for green tinted fruit. 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. Because of a lack of virus symptoms and virus transmitting aphids early in the season, a few plants in all four replications were inoculated with leaves containing virus symptoms and aphids on 19 August. These insect and disease infested leaves were taken from an infected field of cucurbits. Plants were visually assessed for the extent of PM symptoms on 18 September and assessed for virus symptoms on 13 October. In both cases, a subjective rating of 0 to 5 was used, 0 meaning no disease present and 5 indicating the highest level of disease.

Results and Discussion

The beginning of the fall growing season was marked by a low occurrence of virus diseases in the squash plots, but with a significant occurrence of powdery mildew. The season was rainy and an early frost severely injured most plants.

Yellow straightnecks. Of the yellow straight neck varieties, Conqueror III, (Table 1) a transgenic variety, yielded significantly more than the other straightneck varieties and also received a very low virus score. In last year's trial, Conqueror III was one of the lowest yielding under very low virus pressure. Precious II, Cougar, Lioness and Multipick were the next highest yielding varieties, though not significantly lower than Conqueror III. They earned low virus scores. Lioness received the lowest PM rating among straightneck squash, as well as low rating for virus symptoms. Conqueror III, and Precious II had low virus scores, but had average PM scores. XPT 1832, a transgenic variety with the precocious gene, along with Superpik, were lowest yielding in our trial. Cougar and Superpik had the most PM symptoms and Seneca Supreme and Daisy had the most virus symptoms. Despite marginal to bad disease ratings, Multipick, Seneca Supreme and Daisy received the highest appearance ratings, (Table 2) while Precious II received a low appearance rating because of the highly variable fruit color and shape.

Yellow crooknecks. Medallion yielded significantly more (Table 1) than other yellow crooknecks, although it received rather high PM and virus ratings. The next highest yielding crooknecks, Gentry, Destiny III, Dixie, Prelude II and Sunglo all rated low for virus symptoms. As in last year's study, Prelude II and Sunglo had lower PM ratings than the other crooknecks. Prelude II, Sunglo and Supersette rated highest in appearance, (Table 2) with the other cultivars having acceptable appearances.

Zucchini. Of the top five yielding varieties, Radiant yielded the highest, (Table 1) but not significantly higher than Payroll, Wildcat (HMX 0710), Tigress and Zucchini Elite. Of the top yielders, Payroll, Wildcat and Zucchini Elite exhibited relatively good PM resistance, along with the lower yielding Senator. All the zucchini in the trial had low virus ratings. In last year's trial, Cashflow, Sensor (9523) and ACX 45a were some of the hardest hit by PM and these, along with Radiant, Spineless Beauty, Independence II and EXP718, again received high PM scores this year. All the zucchini varieties received acceptable appearance ratings, (Table 2) but Payroll, Wildcat, Tigress and Robuster received the highest scores.

Marketable yields in late plantings can be expected to vary considerably among cultivars from year to year. Differences depend on the resistance package in the cultivar, diseases present in the field, and the growth stage at which the crop becomes infected. Precocious yellow straightneck cultivars still remain an excellent choice for high yields and masking of green fruit symptoms caused by WMV and CMV.

When virus diseases are a serious risk, transgenic virus-resistant cultivars should perform considerably better in most late summer plantings. Conqueror III, Cougar, Lioness and Sunray are recommended for small-scale trial. Multipik and Fortune will remain on our list of suggested cultivars for Kentucky growers in spite of their susceptibility to PM. Precious II has performed well for the second year in a row, but it is not recommended for trial because of the varied appearance observed in this year's trial.

Of the crookneck varieties, Destiny III and Prelude II are recommended for growers. Although not yielding the highest in this trial, they both did well under low virus pressure. Medallion, Gentry and Sunglo are recommended for trial. Among zucchini, Tigress, Zucchini Elite, and Spineless Beauty continue to be recommended. Radiant, Payroll, Cashflow and Senator are recommended for grower trial, as well as Wildcat for its stunning black appearance. Disease resistance in any type of summer squash should be considered when choosing a variety, since productivity often relies on the severity of disease occurring in any particular season.

Acknowledgements

The authors would like to thank the following persons for their hard work and assistance in the successful completion of this trial: Dave Lowry, Phillip Bush, Larry Blandford, Kirk Ranta, Derek Law, Audrey Horrall, Barry Duncil, Courtney Bobrowski, Curtis Gregory, Justin Clark, Dave Spalding, Selvaprasanna Sanjeevijulian, Kalyan Tangirala, Teerasak Tiamdao (Oa), Tanasit Laosomboon (Koh), Spencer Helsabeck and John C. Clark.

Table 1. Yields and powdery mildew assessments for yellow straightneck, crook-neck, and zucchini squash cultivars and breeding lines. Data are means of four replications.

Entry	Source	Type[1]	Mkt. Yield boxes/acre[2]	Disease Rating[3] PM	Disease Rating[3] Virus	Appear. Rating[4]
I. Yellow straightneck and slight semi-crookneck:				18 Sept	13 Oct	
Conqueror III	SW	SN, Tg-3+	1027	2.4	0.3	6.5
Precious II	AC	SN-Py	806	2.6	0.3	4.5
Cougar	SW	SN-Py	732	3.8	1.5	6.5
Lioness	SW	SN	713	1.8	1.0	6.0
Multipik	HM	SN-Py	672	3.3	1.5	8.0
Sunray	SW	SN-Py	643	2.8	2.0	7.0
Fortune	RG	SN-Py	629	3.5	2.3	7.0
Seneca Supreme	SM	SN-Py	626	3.5	2.8	8.0
Daisy	SM	SN-	566	3.1	2.5	7.5
Superpik	HM	SN-Py	544	3.9	2.3	6.5
XPT 1832	SM	SN-Py, Tg-3	384	3.1	1.5	6.0
II. Yellow semi-crookneck or crookneck:						
Medallion	AC	SCN	906	3.3	3.5	6.5
Gentry	RG	sCN	704	3.4	1.5	6.5
Destiny III	SW	sCN, Tg-3	668	3.6	0.0	6.0
Dixie	SM	CN	595	3.5	2.0	6.5
Prelude II	SW	CN, Tg-3	567	1.0	0.3	7.0
Sunglo	RG	sCN	505	1.4	0.8	7.0
Supersette	HM	CN-Py	500	2.5	3.0	7.0
Pic-N-Pic	SW	CN	400	3.5	0.3	6.0
Waller-Duncan LSD (all yellow squash, P=.05).			150	.77	.89	---
III. Zucchini:						
Radiant	SM	Z	1099	3.4	0.3	6.5
Payroll	RG	Z	1080	2.4	0.0	8.0
Wildcat (HMX 0710)	SW	Z	1011	1.8	0.0	8.5
Tigress	SW	Z	951	2.9	0.3	7.5
Zucchini Elite	HM	Z	918	2.1	0.5	7.0
Cashflow	RG	Z	899	3.5	0.5	7.0
Spineless Beauty	RG	Z	874	3.4	0.3	6.0
Independence II	SW	Z,Tg-2	849	3.9	0.0	5.5
ACX 45a	AC	Z	822	3.8	0.0	5.5
Senator	SW	Z	763	1.9	1.3	7.0
Sensor (9523)	SS	Z	763	3.6	0.0	5.0
Dividend	RG	Z	758	3.0	0.0	7.0
Robuster	SS	Z	751	3.0	0.8	7.5
EXP 718	SW	Z	708	3.7	0.3	6.5
Revenue	RG	Z	614	3.0	0.0	6.5
Waller-Duncan LSD (zucchinis, P=.05)			181	1.1	1.4	--

[1]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 15 Sept.: SN = straightneck, CN = crookneck, sCN = semi-crookneck; some cultivars 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.

[2]Number of half-bushel (21lb = 9.52 kg) boxes per acre.

[3] 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 and virus symptoms; assessed by W. Nesmith on 18 Sept and 13 Oct.

[4]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 cultivars and breeding lines. All fruits bulked from four replications of the harvest.

Entry	Type[1]	Color Uniform[2]	Appear rating[3]	Shape/comments/suitability
Conqueror III	SN-Py Tg-3+	2.5	6.5	Light yellow, long fruit with faint longitudinal yellow lines.
Medallion	sCN	3.5	6.5	Light yellow, medium sized bulb.
Precious II	SN-Py	1.5	4.5	Medium yellow to light green, variable shape and color.
Cougar	SN-Py	4.0	6.5	Medium yellow.
Lioness	SN	3.0	6.0	Pale yellow, long cylindrical fruit with thick neck.
Multipik	SN-Py	5.0	8.0	Medium yellow, thick, short fruit.
Sunray	SN-Py	3.5	7.0	Medium yellow.
Fortune	SN-Py	4.0	7.0	Medium yellow.
Seneca Supreme	SN-Py	4.0	8.0	Medium yellow, thick, short fruit.
Daisy	SN	1.5	7.5	Light yellow to slight green.
Superpik	SN-Py	4.5	6.5	Medium yellow.
XPT 1832	SN-Py, Tg-3	4.0	6.0	Medium yellow.
Gentry	sCN	3.0	6.5	Medium yellow, large bulb.
Destiny III	sCN, Tg-3	2.0	6.0	Medium yellow, large bulb.
Dixie	CN	2.0	6.5	Pale yellow.
Prelude II	CN, Tg-3	1.5	7.0	Medium yellow.
Sunglo	sCN	3.0	7.0	Light yellow, smooth fruit.
Supersette	sCN-Py	5.0	7.0	Medium yellow
Pic-N-Pic	CN	4.0	6.0	Yellow to light green, bulbous blossom end.
Radiant	Z	3.5	6.5	Dark green.
Payroll	Z	5.0	8.0	Medium green.
Wildcat (HMX 0710)	Z	5.0	8.5	Very dark green mottled with lt. green.
Tigress	Z	4.5	7.5	Medium green, nice appearance, uniform size and color.
Zucchini Elite	Z	3.5	7.0	Medium green, all a bit curved
Cashflow	Z	3.0	7.0	Dark green, all slightly curved.
Spineless Beauty	Z	3.5	6.0	Medium green, stem extends onto the top of the fruit.
Independence II	Z, Tg-2	4.5	5.5	Medium green, slightly curved.
ACX 45a	Z	4.0	5.5	Black, attractive.
Senator	Z	4.5	7.0	Light green.
Sensor (9523)	Z	4.5	5.0	Dark green, small at top, larger at blossom end.
Dividend	Z	4.0	7.0	Very dark green, slightly curved.
Robuster	Z	4.0	7.5	Medium green, attractive.
EXP 718	Z	3.0	6.5	Medium green, slightly curved.
Revenue	Z	4.0	6.5	Medium green, slightly curved.

[1]Type descriptions based on our observations on 15 Sept. (SN = straightneck, SN-Py = straightneck with precocious yellow gene, CN = crookneck, sCN = semi-crookneck); some cultivars that we considered semi-crookneck may be considered straightneck by the seed company.
[1]Color ratings for yellow squash: 1 = variable color, light green; 5 = bright golden yellow, uniform color; for zucchini, 1 = variable color; 5 = uniform color.
[3]Appearance ratings: 1 = worst; 9 = best taking into account, in order of importance, overall attractiveness, shape, and color.