Powdery Mildew Resistant Butternut Squash
Variety Evaluation, New York 2009

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Powdery mildew is an annual production problem for all cucurbit crops throughout the United States, reducing yield potential and fruit quality when not controlled. Effective control with fungicides alone has been challenged by the development of fungicide resistance to key chemistries. The goals of this experiment, which is part of a multi-year variety evaluation project, were (1) to determine whether hybrids with homozygous resistance (e.g., two copies of the powdery mildew resistance gene, PMRR) provide better suppression of powdery mildew in butternut squash than varieties with heterozygous resistance (PMR), and (2) to evaluate yield and fruit quality of the varieties. In order to have good comparisons, PMR and PMRR experimental hybrids were obtained from two plant breeders. A susceptible hybrid was also obtained from one of these breeders. Three additional PMRR hybrids were obtained from another source.

Materials and Methods
A field experiment was conducted at the Long Island Horticultural Research and Extension Center in Riverhead on Haven loam soil. The field was plowed on April 30 and conventionally tilled on May 14 and June 1. A blend of 19-10-12 controlled release fertilizer (containing 65% of N as ESN, a controlled release formulation) plus muriate of potash (0-0-60) at 100 lbs/A was spread on June 10 and then incorporated by disking. Black plastic mulch and drip tape were laid on June 15. Seeds were sown on May 29 in the greenhouse. Seedlings were transplanted into the plastic-covered beds on June 16. Water was provided as needed through drip irrigation lines located beneath the mulch.

Weeds were controlled between plastic mulch strips by applying Strategy® (3 pt/A) and Sandea® (0.5 oz/A) on June 17 with a shielded herbicide sprayer and by hand weeding. Cucumber beetles were managed with Admire 2F® (0.0007 fl oz/plant) applied after transplanting as a soil drench around transplants on June 29 and with Asana XL® (9.6 oz/A) applied to foliage on June 24 and July 1. No fungicides were applied to control powdery mildew. Ridomil Gold EC® 1 pt/A + SprayHandler at 8 fl oz/A were applied to soil on June 8 and incorporated by disking for Phytophthora blight (Phytophthora capsici). The following foliar fungicides were applied preventively for downy mildew (Pseudoperonospora cubensis) and Phytophthora blight: ProPhyt® (4 pts/A) on June 24; Forum 4.16SC® (6 oz/A) on July 27, August 8 and 27 Aug, and September 13 and 24; and Ranman 400SC® (2.75 fl oz/A) on July 17, August 1 and 16, September 4 and 18, and October 1.

Plots were three adjacent rows each with three plants spaced 24 inches apart. Rows were spaced 68 inches apart. Within each of the three rows between each plot a plant of Gentry summer squash, a susceptible variety, was planted to separate plots and provide a source of inoculum. A randomized complete block design with four replications was used.

Upper and lower leaf surfaces of 10 to 30 leaves in each plot were assessed for powdery mildew on July 15, 22, and 31, August 14, and September 1. Initially, the examined leaves were selected
from the oldest third of the foliage based on leaf appearance and position in the canopy. As disease progressed, mid-aged and young leaves also were examined. Powdery mildew colonies (spots) were counted; severity was estimated when colonies had coalesced or were too numerous to count. Colony counts were converted to severity values using the conversion factor of 30 colonies/leaf = 1%. Average severity for the entire canopy was calculated from the individual leaf assessments.

Squash fruit were harvested and weighed on October 8. Three representative fruit per plot were selected for measuring fruit width, fruit length, and cavity width and for assessing sugar content, which was done with a hand-held refractometer using fruit samples that were frozen and then thawed. Fruit characteristics were also evaluated and overall appearance was rated on a scale of 1 to 5 with 1 = poor and 5 = best.

Average monthly high and low temperatures (°F) were 73/58 in June, 80/64 in July, 83/68 in August, and 74/58 in September. Rainfall (inches) was 6.43, 4.82, 2.01, and 2.39 for these months, respectively.

**Results and Discussion**

Powdery mildew symptoms were first seen on July 22 (36 days after transplanting) in 19 of the 44 plots. Symptoms were found in only one of the 12 plots planted to a PMRR hybrid. Powdery mildew was not consistently less severe for PMRR hybrids compared to PMR hybrids on subsequent assessment dates (Table 1; not all data included in table). However, Bugle (PMRR) had the lowest average severity for most assessments. Severity remained low through the August 14 rating, and then increased to high levels by September 1. The susceptible hybrid was the most severely affected hybrid on July 31, but not on September 1, which could have been due to the death of the most severely affected leaves before September 1. Lack of significant differences among hybrids in severity on September 1 may be partly due to the large degree of variation among plots. Severity was at a moderate level for the resistant hybrids on September 1 (exceeding 10% on upper leaf surfaces for most hybrids and 24% on lower surfaces for all). This may reflect a change in the pathogen such as it is able to overcome host resistance or reduced suppression as plants reach maturity. The last assessment was 95 days after seeding. Unfortunately, severity was not assessed during the last two weeks in August. Severity was not assessed after mid-August in a similar experiment in 2008 in which severity remained low.

Fruit of JWS 61108 had the numerically highest sugar content; it was only significantly greater than Quantum and AF 7514. Honey Nut and JWS 61107 were bred to produce personal-size fruit, which are especially popular for CSA boxes. Honey Nut produced the smallest fruit and the greatest number of fruit per plant. Quantum produced the greatest estimated weight of fruit per plant while Honey Nut and Waltham produced the least (Table 1). All varieties produced fruit with acceptable characteristics, which were rated at least 7 out of 9.

**Butternut Squash Variety Fruit Descriptions and Assessments**

**Waltham**

Peachy, nude color and medium in size. Medium thick neck. Slightly irregular shapes but a good size. Overall rating of 8 out of 9.

**Metro (PMR)**

Dark peach color and small to medium in size. Slightly bulbous blossom end, medium thick neck, and a bulbous stem end. Uniform size and shape. 8.5 out of 9.
Bugle (PMRR)
Light peach color. Small to medium in size. Neck is long and thin with a short bulbous blossom end. Irregular shapes and sizes. 7.5 out of 9.

Betternut 401 (PMR)
Medium to dark peach in color with slight green stripes at stem end. Medium size fruit. Very long and narrow neck and a bulbous stem end. 7.5 out of 9.

Quantum (PMR)
Light to medium peach in color. Mostly medium to large in size but some variability in shape and size. Narrow, medium thick necks. Good yields. Overall appearance rating 8 out of 9.

AF 7514 (PMR)
Medium to dark peach in color. Large fruit. Very uniform fruit in shape, color, and size. Moderately thick neck and a bulbous blossom end. 8.5 out of 9.

Honey Nut (PMR)
Very dark peach to orange in color. Small, personal-size fruit. Uniform shapes and sizes. Short, medium thick necks. 8 out of 9.

HMX 7732 (PMR)
Fruit is medium to dark peach in color and large in size. Medium long, thick necks. Good size and shape. Uniform. 8.5 out of 9.

WSXP1037 (PMRR)
Fruit medium peach color and medium to large in size. Neck is narrow to medium thick. Slightly irregular in shape, size, and color. 8 out of 9 rating.

JWS 61107 (PMRR)
Dark peach in color and rather smaller in size. Good shape. Bulbous blossom end and neck uniform in width. Overall rating 8 out of 9.

JWS 61108 (PMR)
Medium peach color and medium to large in size. Some green striping near the stem end. 8 out of 9.

Acknowledgments
Project funded by the Friends of Long Island Horticulture Grant Program. Seed were donated by the companies listed in Table 1. Pesticides were donated by BASF Corporation, Bayer CropScience, DuPont Crop Protection, Gowan Company, FMC Corporation, Helena Chemical Company, and Syngenta Crop Protection.
### Table 1. Suppression of powdery mildew and yield for butternut squash hybrids compared on Long Island, NY, in 2009.

<table>
<thead>
<tr>
<th>Variety or Experimental (resistance)</th>
<th>Seed Source</th>
<th>Powdery Mildew Severity (%)</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Upper Leaf Surface</td>
<td>Lower Leaf Surface</td>
</tr>
<tr>
<td></td>
<td></td>
<td>July 31&lt;sup&gt;3&lt;/sup&gt;</td>
<td>Aug. 5&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>Bugle (PMRR)</td>
<td>RU</td>
<td>0.0017 b</td>
<td>0.00 a</td>
</tr>
<tr>
<td>JWS 61107 (PMRR)</td>
<td>JS</td>
<td>0.0017 b</td>
<td>0.00 a</td>
</tr>
<tr>
<td>WSXP1037 (PMRR)</td>
<td>HM</td>
<td>0.0033 b</td>
<td>0.11 a</td>
</tr>
<tr>
<td>AF 7514 (PMR)</td>
<td>SK</td>
<td>0.0250 ab</td>
<td>0.00 a</td>
</tr>
<tr>
<td>JWS 61108 (PMR)</td>
<td>JS</td>
<td>0.0500 ab</td>
<td>0.00 a</td>
</tr>
<tr>
<td>Metro (PMR)</td>
<td>JS</td>
<td>0.0342 ab</td>
<td>0.03 a</td>
</tr>
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<td>Quantum (PMR)</td>
<td>SK</td>
<td>0.0000 b</td>
<td>0.00 a</td>
</tr>
<tr>
<td>HMX 7732 (PMR)</td>
<td>HM</td>
<td>0.0008 b</td>
<td>0.45 a</td>
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<td>Honey Nut (PMR)</td>
<td>HMO</td>
<td>0.0008 b</td>
<td>0.00 a</td>
</tr>
<tr>
<td>Butternut 401 (PMR)</td>
<td>SI</td>
<td>0.0017 b</td>
<td>0.00 a</td>
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<td>Waltham (S)</td>
<td>JS</td>
<td>0.2750 a</td>
<td>0.74 a</td>
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<tr>
<td>P-value (treatment)</td>
<td></td>
<td>0.0385</td>
<td>0.5522</td>
</tr>
</tbody>
</table>

<sup>1</sup>Exact colony counts were made when possible and severity was estimated using the conversion factor of 30 colonies/leaf = 1%. Data were transformed from percentages by a square root transformation when needed to obtain normality of variance before analysis of variance was performed. The table has de-transformed means. Only older leaves were assessed on August 8. AUDPC values were calculated for canopy severity, which included assessments of young and mid-aged leaves examined on August 15.

<sup>2</sup>PMRR indicates homozygous resistance; PMR indicates heterozygous resistance; S indicates susceptible, no known resistance genes.

<sup>3</sup>Numbers in each column with a letter in common are not significantly different from each other (Tukey’s HSD, P=0.05).