2016

Butternut Squash Variety Trial URI 2016

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Introduction

The objective of this trial was to evaluate powdery mildew resistance, yield, and quality in large-fruited varieties suited to processing, cut-and-peel, or sales to food service. Waltham Butternut was used as the standard to which 15 other entries were compared.

The trial was conducted at the University of Rhode Island's Gardiner Crops Research Center in Kingston RI. The soil is Bridgehampton silt loam with a pH of 6.5 and 4 to 5% organic matter. The summer of 2016 was warm and dry, with average high temperatures of 79°F in June, 85°F in July, 86°F in August, and 78°F in September. Total growing degree days (base 50) was 2,506. Total rainfall was only 8.9 inches, 59% of normal.

Methods

Butternut squash was seeded May 30. Between-row spacing was 5 ft; within row spacing was 2 ft for short vine types and 3 ft for standard types. Plot size was 50 ft long x 15 ft wide with each plot containing 3 rows. Experimental design was randomized complete block with 4 replications. Nitrogen and potassium were supplied at planting by banding 12-1-12 in the furrow at a rate sufficient to supply 40 lbs N/acre. An additional 40 lbs N/acre was applied by side dressing when vines began to run. Seed treatment varied by supplier, resulting in a mix of varieties treated with Farmore FI400, varieties treated with Thiram, and untreated varieties. Entries that were not treated with Farmore FI400 received a furrow drench of Admire Pro at 0.6 oz/1000 ft prior to planting. Weeds were controlled with ethalfluralin applied before crop emergence and halosulfuron applied when squash had 5 true leaves. The herbicides were only partially effective and were supplemented by hand cultivation. No fungicides were applied. Overhead irrigation was provided with a Kifco water reel, but was insufficient to prevent drought stress during August.

Table 1. Butternut squash trial entries and suppliers. Waltham H and Waltham J refer to strains of this OP variety from Harris and Johnny's, respectively. Days to maturity (DTM) is as provided by supplier.

Variety	Source	Vine Type	In-row spacing	Seed Treatment	DTM
Atlas	Seedway	restricted vine	3 ft	Farmore FI400	90
Avalon	Harris	Long vine	3 ft	Thiram	88
Betternut 1744	Rupp	semi-bush	2 ft	Farmore FI400	80
Betternut 23	Rupp	vine	2 ft	Farmore FI400	115
Betternut 900	Rupp	semi-bush	2 ft	Farmore FI400	80
Butterfly	Harris	semi-bush	2 ft	Thiram	90
Granite	Siegers	Long vine	3 ft	Thiram	90
JWS 61726	Johnny's	vine	2 ft	None	?
JWS 61888	Johnny's	semi-bush	2 ft	None	?
Prism	Siegers	Restricted vine	2 ft	Thiram	85
RBX2109A	Rupp	vine	2 ft	Farmore FI400	110
RBX2651	Rupp	vine	2 ft	Farmore FI400	110
Ultra	Seedway	Long vine	3 ft	Thiram	90
Waltham H	Harris	Long vine	3 ft	Farmore FI400	97
Waltham J	Johnny's	Long vine	3 ft	None	105
Yukon	Siegers	Long vine	3 ft	Thiram	110
Zodiac	Seedway	Long vine	3 ft	Farmore FI400	110

Results

Stand Establishment: Seedcorn maggot levels were unusually high in May and June of 2016 and caused extensive damage to butternut squash. Farmore FI400 was effective protection, but Admire Pro applied in-furrow was not. Farmore-protected entries averaged 92% seed emergence, compared to only 25% emergence for Admire Pro-protected entries. Plots with poor establishment were reseeded June 21. Yield values were adjusted for number of plants per plot based on stand counts taken July 13.

Growth Habit: One challenge with growing Waltham butternut is that the long vines require wide plant spacings and prohibit cultivation for much of the growth period, but the foliage is not dense enough to suppress weeds. Species with tolerance to the herbicides applied at planting can easily grow through the squash canopy and set large amounts of seed, creating problems for future crops. Some new varieties have improved density. Yukon, Granite, and Avalon had long vines with dense foliage, resulting in excellent ground cover and weed suppression. Prism, Atlas, Zodiac and JWS 61726 were able to fully occupy the space between rows, but foliage was not dense – similar to Waltham. JWS 61888 and Betternut 1744 formed very dense stands, but the short vines were not able to completely occupy the space between rows. In contrast, Betternut 900 and Betternut 23 had very open canopies with poor ground cover.

Disease Resistance: The trial was visually rated for powdery mildew severity in mid-August and again in mid-September. Bacterial wilt damage was assessed in mid-August. Canopy retention was assessed in mid-September; powdery mildew, bacterial wilt, and drought stress were primary causes for defoliation.

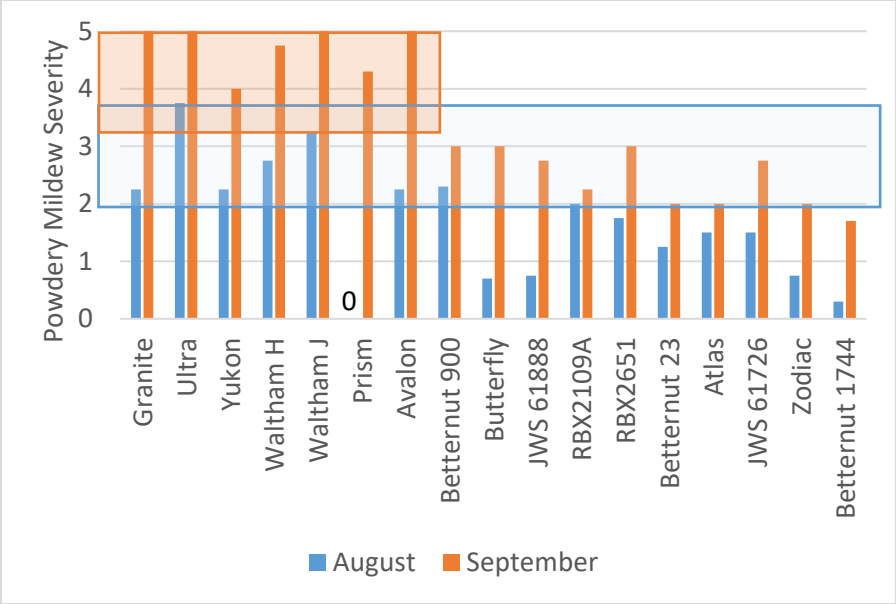

Figure 1. Powdery mildew severity in August (LSD = 2.0) and September LSD = 1.5). A score of 0 indicates no disease, while a score of 5 indicates severe disease with extensive sporulation on both old and new leaves. The blue and orange boxes indicate entries that were similar to Ultra, which was the most susceptible entry.

The primary reason for applying systemic insecticide to butternut squash at planting (either as seed treatment or furrow drench) is to protect against cucumber beetle feeding and bacterial wilt transmission. In 2016 striped cucumber beetle emerged on June 19 at our location, when squash plants had 1-2 true leaves. Beetle feeding did not cause severe damage, and bacterial wilt severity was unrelated to either seed treatment or genetics. Bacterial wilt severity did vary significantly with field location; plots closer to the pumpkins had less bacterial wilt. This was presumably because the beetles preferred the pumpkins.

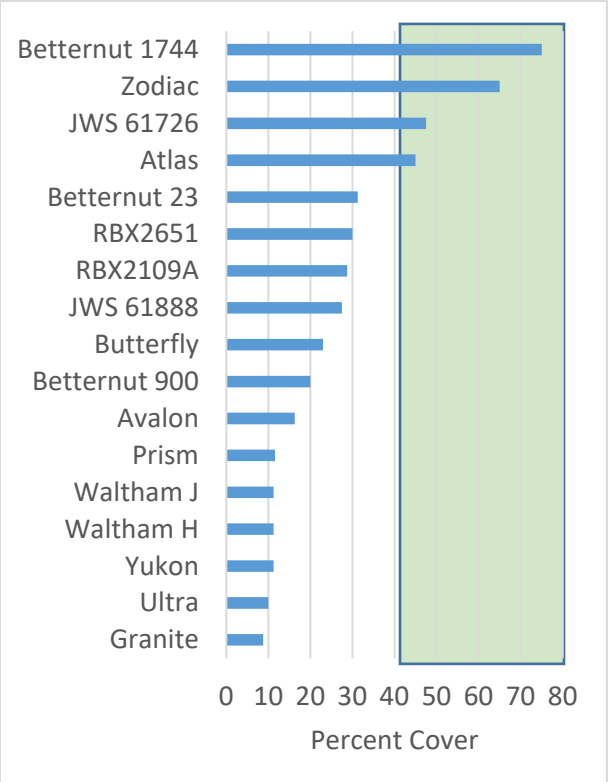

Figure 2. Percent canopy cover remaining on September 16, 85 to 105 days after seeding. The green box indicates entries that are statistically similar to Betternut 1744, and superior to Waltham. LSD = 21.

Ultra was the most susceptible to powdery mildew, developing significant disease by mid-August. Prism was the least susceptible entry in August, with no disease present. Entries with a mean score of 2 or above were statistically similar to Ultra, while those with scores below 2 were similar to Prism. By September, Ultra and several other entries had average scores of 5, indicating severe powdery mildew on all plants. Betternut 1744 had the least disease, with some plots remaining disease-free and others having only scattered powdery mildew

sporulation on older leaves. Entries with September scores above 3 were fully susceptible, similar to Ultra. Entries with scores below 3 were tolerant, similar to Betternut 1744. Leaf retention was strongly associated with powdery mildew severity. All fully susceptible entries had less than 20% canopy cover by mid-September, and all crown leaves had dropped. In contrast, Betternut 1744 averaged 75% cover, with many healthy crown leaves. Zodiac, JWS 61726, and Atlas were statistically similar to Betternut 1744.

Fruit Size: At harvest we selected the largest and smallest mature fruits from each plot, as well as three typical fruit. These fruits were weighed, and length and neck circumference were measured. Fruit size was highly variable within each plot, likely due to drought stress reducing size on fruit set in August.

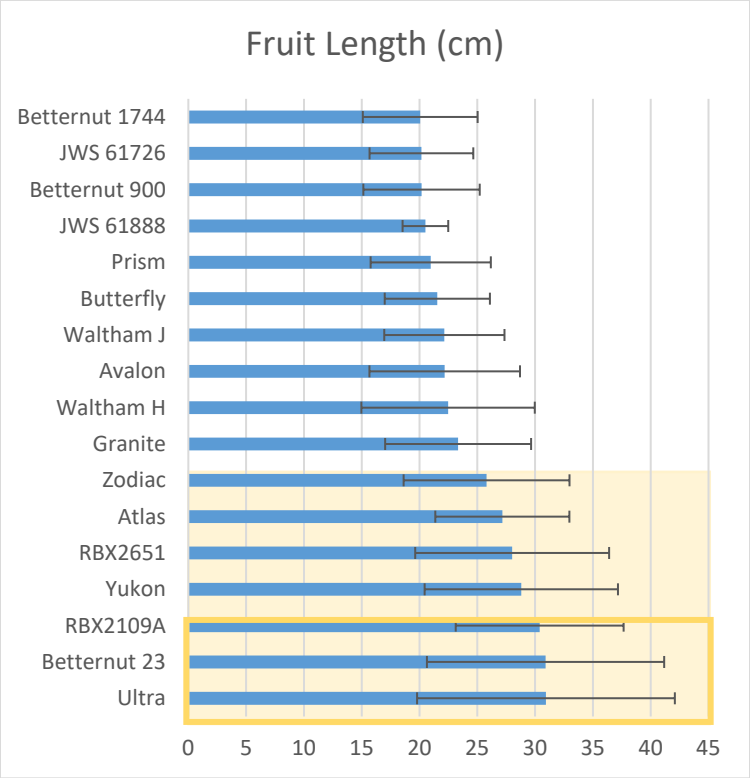

Figure 3. Average fruit length in centimeters. LSD = 2.3. Entries within the gold outline are statistically similar to Ultra. Entries within the yellow box are significantly longer than Waltham. Error bars indicate the size range of fruit.

Ultra had the longest fruit, averaging 31 cm (12 in.) but many fruits had curved necks. Betternut 23 and RBX2109A were similar in length but with better fruit shape. The longest fruits for Ultra and Betternut 23 exceeded 40 cm (15 in.) but there were also many standard-size fruit. JWS 61888 had small fruit, similar to Betternut 1744, but significantly better uniformity of fruit size than the other entries.

Neck circumference ranged from 32 cm (12.7 in.) for Atlas to 24 cm (9.7 in.) for Betternut 900. Atlas was the only entry to have significantly fatter fruit than Waltham. Betternut 23 fruit were long but slender, significantly slimmer than Waltham but similar to Betternut 900.

Atlas had the heaviest fruit, averaging 5 lbs and ranging up to 8 lbs. Ultra and Yukon were similar in weight. Betternut 23 was significantly lighter than Atlas but still significantly heavier than Waltham. All entries weighed in at the bottom of their normal fruit weight range, and many fruits were lighter than normal, likely due to drought stress. Weight data are based on marketable fruit, so do not include immature or under-developed fruits.

Yield: Yield potential is based on fruit size, the number of fruits per plant, and the number of plants per acre – which reflects both plant spacing and establishment. We harvested a 40 ft x 10 ft area in the center of each plot and counted and weighed the harvested fruits. This method was chosen to minimize problems with vines mixing across plot boundaries. Only fully mature fruit with no sign of damage or

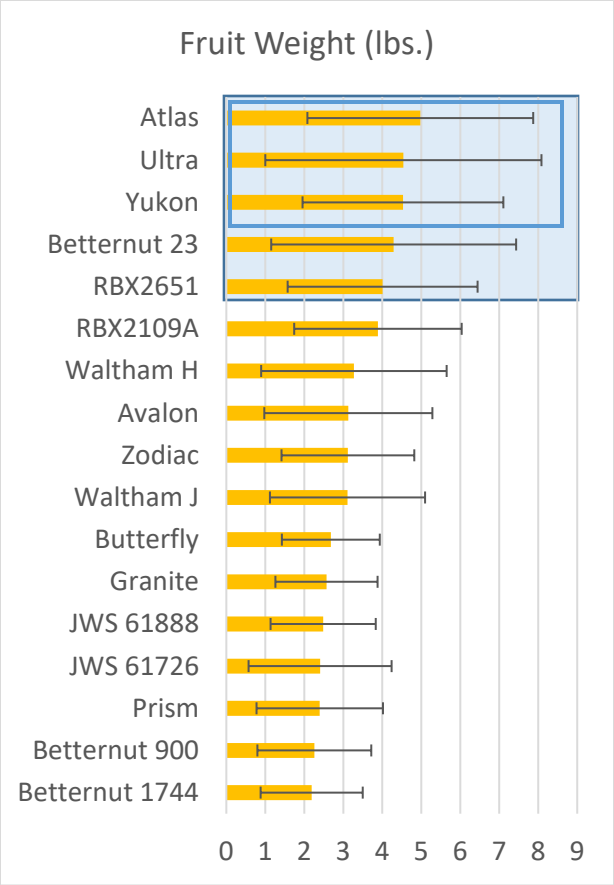

Figure 4. Fruit weight in pounds (LSD = 0.6 lb). Error bars indicate the weight range between largest and smallest fruits. Entries within the blue frame are similar to Atlas, while those within the blue box are significantly heavier than Waltham.

Table 2. Fruit yields per plot and per plant for each variety. Entries with less than one fruit per plant had large numbers of unmarketable fruit.

Fruit Quality: There were no consistent differences in fruit color visible to the naked eye, so data were not collected. Exterior color for all fruits was pale tan. Interior color ranged from deep orange to pale orange, with color intensity varying between fruit within variety and probably reflecting fruit maturity.

disease were harvested. When expressed as weight, yields were similar across all plots, averaging 9.3 tons/acre. Significant differences did exist between varieties when yields were expressed as fruit counts. Betternut 900 yielded the most at 77.7 fruit per plot, while Betternut 23 yielded the least at only 32.5 marketable fruit. The number of marketable fruit per plant ranged from 0.5 for Betternut 23 to 1.9 for Granite. The low number of marketable fruit per plant for Betternut 23 was due to extensive black rot. Waltham produced 1.6 fruit per plant. Fruit weight per plant ranged from 5 lb for Avalon down to 2 lb for Betternut 23; Waltham was one of the heavier producers at 4.6 lbs per plant.

Variety	Per Plot	Per Plant
Atlas	41.5	0.9
Avalon	73.0	1.7
Betternut 1744	65.7	1.0
Betternut 23	32.5	0.5
Betternut 900	77.7	1.1
Butterfly	73.7	1.3
Granite	72.0	1.9
JWS 61726	71.5	1.3
JWS 61888	75.5	1.3
Prism	61.7	1.0
RBX2109A	40.0	0.6
RBX2651	52.0	0.7
Ultra	34.5	0.8
Waltham H	70.0	1.5
Waltham J	50.0	1.6
Yukon	49.3	1.3
Zodiac	58.3	1.3
LSD	*21*	*0.4*

Sugar content differed significantly among entries both before and after curing. The degree of response to curing also differed. We sampled three typical fruit per plot immediately after harvest, and an additional three fruit per plot after curing for 14 days at 80°F. A 1-inch-thick slice was cut from the neck of each fruit. Slices were stored in plastic bags in the freezer prior to juice extraction. To prepare for

extraction, slices were thawed at room temperature overnight then squeezed in a garlic press to extract juice. Sugar content was measured as %Brix using a hand-held refractometer.

Sugar content prior to curing ranged from 5.8% for Ultra to 9.8% for Betternut 1744. After curing, Ultra was still the least sweet at 5.9%, while Betternut 1744 had become even sweeter, averaging 12% soluble solids. Curing significantly increased sugar content overall, but not for all entries. Betternut 1744, JWS 61888, Betternut 23, and Zodiac all had significantly higher sugar levels after curing.

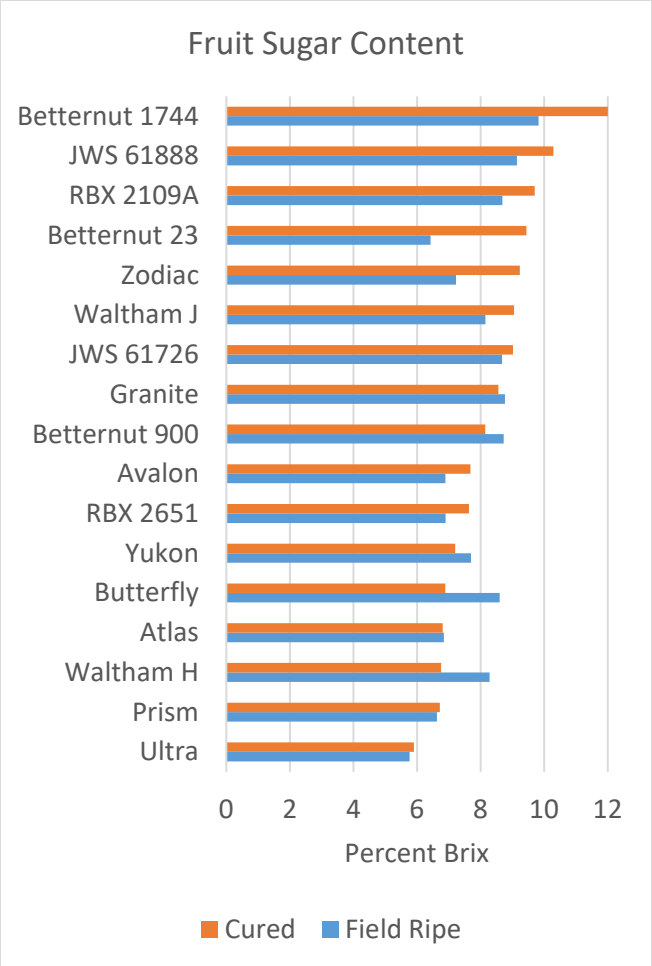

Figure 5. Sugar content of butternut fruit before and after curing. No entries were sweeter than Waltham prior to curing, and only Betternut 1744 was sweeter after curing. LSD = 1.0 for Field Ripe, and 1.3 for Cured.

Conclusions

Ultra and Betternut 23 had the longest fruit of the named entries, while Atlas, Yukon, and Ultra had the heaviest fruit. Yukon had the highest yields per plant of these entries, while Atlas and Betternut 23 had the best resistance to powdery mildew. Betternut 23 also responded well to curing, and after curing had significantly sweeter fruit that the other large-fruited entries. Unfortunately, Betternut 23 and its sister entry RBX 2109A developed extensive black rot infection, severely reducing the amount of marketable fruit. It is unclear if the entries are just extremely susceptible or the seeds were infected. Very little blackrot was seen on any of the other entries. Ultra is not recommended due to curved necks and poor flavor.

Zodiac fruit are similar in size and length to Waltham fruit, and the flavor is comparable. However, Zodiac has significantly improved powdery mildew resistance.

Betternut 1744 had the best powdery mildew resistance and the best fruit quality in the trial. However, it also had the smallest fruit, and averaged only one fruit per plant, which is low for a small-fruited variety. The foliage was very dense and vines were short, suggesting that this variety could be planted at higher density than was used in this study. JWS 61888 is similar to Betternut 1744 in fruit characteristics

and growth habit. Yield is higher at 1.3 fruit per plant, but JWS 61888 is somewhat more susceptible to powdery mildew.

Acknowledgements

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