High Plant Populations and Plasticulture Techniques Increase Winter Squash Yield

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Trials were undertaken in 2001 and 2003 at Cornell University's research farm in Eastern New York to identify optimal in-row spacing and nitrogen fertilization rates for acorn and butternut squashes grown on raised beds using black plastic mulch and drip irrigation. The in-row spacing treatments evaluated in this trial were 12, 24 and 36 inches. A between-row spacing of 72" was used in 2001 and 60' was used in 2003. In 2001, all treatments received a broadcast fertilizer application that provided 40 lb nitrogen (N)/acre. Fertigation treatments included an additional 15, 30 and 45 lb of liquid N/acre in 15 lb incremental applications. The materials and methods used in this trial can be found in footnotes to the tables. In 2003, no broadcast fertilizers were used; a full-spectrum fertilizer designed to deliver 30 lb/acre each of N, P and K was injected into the drip irrigation system.

The 2001 study.

The two winter squashes responded differently to the nitrogen treatments (Tables 1 and 2). The 40 lb pre-plant N application plus two fertigation applications (of 15 lb N/acre each), providing a total of 70 lb N/acre, generated the greatest yields of butternut squash. Lower yields were achieved when N was applied at the lower rate of 55 lb/A, and fertilizer in excess of 70 lb N/A failed to appreciably increase the number of butternut fruit or average fruit weight. Acorn squash yields were not influenced by the N rates investigated in this trial. The acorn squash, which matured about three weeks earlier than the butternut, was probably unable to utilize the nitrogen provided by the last two fertigation applications.

Table 1. Butternut squash yield responses to three nitrogen fertilizer rates

Nitrogen Fertilizer (lb/A)	Fruit Number (No./30' of row)	Fruit Weight (lb/30' of row)	Average Weight/ Fruit (lb)	Yield per Acre (lbs)
55	27.7	82.8	3.0	18,500
70	33.4	101.0	3.0	22,500
85	31.9	100.3	3.1	22,300

Table 2. Acorn squash yield responses to three nitrogen fertilizer rates

Nitrogen Fertilizer (lb/A)	Fruit Number (No./30' of row)	Fruit Weight (lb/30' of row)	Average Fruit Weight (lb)	Yield per Acre (lbs)
55	36.1	72.6	2.3	16,200
70	35.3	73.1	2.2	16,300
85	37.5	75.4	2.3	16,800

To our surprise, the 12" in-row spacing provided the greatest yields of marketable fruit in both butternut and acorn squashes (Tables 3 and 4). The 24" in-row spacing, which is

probably the most commonly used in-row spacing, also produced good results. Differences were most pronounced in the acorn squash trial, where the yield of medium to large fruits was 30% greater in the 12" than in the 24" spacing. Jumbo fruits yielded marginally less in the closer spacing. The greater yield from the close in-row spacing was attributable to the increase in fruit set that was coincident with the increase in plant density.

From our 2001 study, it appears that growing acorn and butternut squash using raised beds, black plastic mulch and drip irrigation, is best done using a 12" in-row spacing and a total of 55 and 70 lb N/acre, for acorn and butternut squash, respectively.

Table 3. Butternut squash yield responses to three in-row spacings

In-Row Spacing (inches)	Fruit Number (No./30' of row)	Fruit Weight (lb/30' of row)	Average Fruit Weight (lb)	Yield per Acre (lbs)
12"	33.1	99.5	3.0	22,200
24"	30.1	95.9	3.2	21,400
36"	30.6	92.6	3.0	20,600

Table 4. Acorn squash yield responses to three in-row spacings

In-Row Spacing (inches)	Fruit Number (No./30' of row)	Fruit Weight (lb/30' of row)	Average Fruit Weight (lb)	Yield per Acre (lbs)
12"	42.6	83.3	2.2	18,600
24"	35.6	72.4	2.3	16,100
36"	31.8	66.6	2.3	14,900

Notes: Plots were 30' long and replicated 3 times. Seeds were sown on 5/25/01 into 72-cell flats and transplanted on 6/19/01 into black plastic with drip irrigation. We used Waltham butternut and Taybelle acorn varieties (Siegers Seed Company). All plots received 40lbs actual N-P-K using 15-15-15, applied through mulch layer at time of bedding. Plots were harvested on 9/11/01. Fruit was graded, counted and weighed on 9/13/01. Nitrogen applications were made in 15 lbs/acre increments on 7/9, 8/3, and 8/17. Plots were chemigated for striped cucumber beetles on July 24, 2001with Admire at a 16 fl oz/acre rate. No fungicides were used.

The 2003 study.

In 2003, an in-row spacing of 24" was used throughout the trial. The acorn squashes exhibited a yield response only at the very highest rate of N (Tables 5 and 6). The highest N rate (75 lb/A) increased the number of fruits produced per plant, which, in turn, increased yields. Interestingly, 'Table Ace,' the older variety of the two acorn squashes, was more responsive to the N rate than 'Autumn Delight,' a relatively new, powdery mildew-tolerant variety. The selection of acorn squash variety is clearly as important as selecting a fertilizer rate: yields of 'Autumn Delight' using 30 lb N/A were greater than those of 'Table Ace' using 75 lb N/A.

Table 5. 'Autumn Delight' yield responses to four nitrogen rates

Nitrogen Rate (lb/A)	Fruit Number (No./16' of row)	Fruit Weight (lb/16' of row)	Average Fruit Weight (lb)	Yield per Acre (lbs)
30	21.3	37.8	1.8	20,600
45	19.1	33.7	1.8	18,300
60	20.2	33.3	1.6	18,000

75	24.2	42.1	1.7	22,900

Table 6. 'Table Ace' yield responses to four nitrogen rates

Nitrogen Rate (lb/A)	Fruit Number (No./16' of row)	Fruit Weight (lb/16' of row)	Average Fruit Weight (lb)	Yield per Acre (lbs)
30	18.0	29.7	1.7	16,200
45	16.2	25.9	1.6	14,100
60	15.8	26.1	1.7	14,200
75	24.2	34.6	1.4	18,800

In 2003, the butternut squashes mimicked the pattern seen in the acorn squashes (Tables 7 and 8). A yield response to increasing N rates was in evidence in both varieties, as was the case in 2001, but the bigger response came from the older variety, 'Waltham.' In addition, 'Avalon,' the newer variety, out-yielded the older 'Waltham', even when 'Avalon' was given the lowest rate of N and 'Waltham' was given the highest rate.

Table 7. 'Avalon' yield responses to four nitrogen rates

Nitrogen Rate (lb/A)	Fruit Number (No./16' of row)	Fruit Weight (lb/16' of row)	Average Fruit Weight (lb)	Yield per Acre (lbs)
30	14.0	40.8	2.9	22,200
45	13.6	35.0	2.6	19,000
60	11.8	31.7	2.7	17,200
75	15.2	43.9	2.9	23,900

Table 8. 'Waltham' yield responses to four nitrogen rates

Nitrogen Rate (lb/A)	Fruit Number (No./16' of row)	Fruit Weight (lb/16' of row)	Average Fruit Weight (lb)	Yield per Acre (lbs)
30	10.2	25.1	2.5	13,700
45	12.8	28.8	2.3	15,700
60	11.7	27.9	2.4	15,200
75	14.2	37.4	2.6	20,300

Notes: Plots were 16' long and replicated 3 times. Seeds were sown on 6/5/03 into 98-cell flats and transplanted on 6/20/03 into black plastic with drip irrigation. All squashes in this trial were grown using a 24' in-row spacing. Plots were harvested on 10/1/01. Nitrogen applications were made in 15 lbs/acre increments on 7/20, 8/10, and 8/30.

These studies suggest that high yields of acorn and butternut squashes grown using plasticulture techniques may be obtained by selecting good varieties, using high plant populations, and by choosing modest fertilizer rates. It appears that yields might be increased above those seen here by increasing fertilizer applications.