2023 North Carolina Zucchini Squash Cultigen Evaluation Study

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Zucchini Squash Cultigen

Evaluation Study

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General Cultural Practices

This zucchini squash study was grown on black plastic mulch that was painted white to mitigate heat stress and fertigated using drip tube. Pesticides used on all plots were chemicals labeled for that crop.

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Disclaimer

This publication presents data from the zucchini squash cultigen evaluation study conducted during 2023. Information in this report is believed to be reliable but should not be relied upon as a sole source of information. Limited accompanying detail is included but excludes some pertinent information, which may aid interpretation.

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Introduction

Summer squash production in North Carolina totaled 3,200 acres harvested in 2022, a value of approximately $15 million. Acreage has decreased from 3,500 acres in 2021 and 3,600 acres in 2020. However, the price per unit (cwt) has increased from $21.50/cwt in 2021 to $37.50/cwt in 2022 (NC Ag Stats).

Late season summer squash plantings in North Carolina typically experience higher incidence of disease and insect pressure since they are harvested in the fall, when environmental factors are more favorable for pests and pathogens. Virus pressure was an important factor in this study and increased throughout the season, having a large impact on some zucchini cultigens.

In 2023, Dr. Schultheis and the Cultural Management Program in the Horticultural Sciences Department at NC State University conducted an evaluation of 19 zucchini squash cultigens from 8 seed companies at the Central Crops Research Station in Clayton, NC. The zucchini entries were evaluated for yield, virus incidence, and quality characteristics such as color, speckling, and shape. The results from the study, methods, and representative photos are present below. All cultigen photographs were taken on 15 September 2023 at the sixth harvest (Figures 2-20).

Materials and Methods

Sowing and Field Preparations

Seeds were sown on 17 July 2023. Hills with seed skips were replanted 7 days after the initial planting to maximize plant stand counts in each plot. Final stand counts were taken 15 September 2023.

The field planting site was located at the Central Crops Research Station in Clayton, NC. The zucchini squash were planted in block G5; a Norfolk loamy sand soil type. Black polyethylene plastic (1.25 mil thick, high density plastic film, 54 inches wide; TriEast Ag Group, Inc., Clinton, NC) was laid out in the field on 30 March 2023. The black plastic was painted white on 12 July 2023 to reduce the temperature beneath the plastic and allow for better germination and growth.

Fertilizer and Pest Management

A total of 400 lb/ac of 12-6-24 was applied broadcast (pre-plant) to the entire study area on 24 March 2023. Drip tape (NETAFIM, 12 in spacing, 0.24 gph; NETAFIM, Tel Aviv, Israel) was installed beneath the plastic mulch to fertigate the crop throughout the growing season. Liquid fertilizer with 4-0-8 analysis was applied through drip tape fertigation 23 times on the following dates: 2, 9, 14, 16, 18, 21, 23, 25, 28, 30 August; 1, 6, 13, 18, 20, 22, 25, 27, 29 September; 2, 4 October. A total of 100.5 gal of 4-0-8 liquid fertilizer was applied throughout the growing season; 165 units of N and 330 units of K. The zucchini plants were not responding to the fertigation initially. We theorized that the pre-plant fertilizer leached out of the soil due to heavy rains (Figure 1a) in the time between applying the fertilizer and planting the zucchini and that the liquid fertilizer applied after planting was insufficient. Thus, we increased the fertilizer rate starting 14 August and the plants responded with expected growth, reaching their appropriate size before harvests began.

Fungicides (Table 1) and insecticides (Table 2) were applied as needed and as directed by the label for that crop (NC Ag Chem Manual). Different products were rotated to avoid potential development of resistance.

Table 1. Fungicides Zucchini Squash Cultigen Study 2023, Clayton, NC.		
Product	**Rate per acre**	**Application Date(s)**
Zampro	14 oz	11-Aug, 20-Sep
Pristine	18.5 oz	11-Aug, 30-Aug
Vivando	14 oz	16-Aug
Zilker SC	2.75 oz	16-Aug, 20-Sep
Bravo Weather Stik	2 pt	23-Aug, 13-Sep
Switch	11 oz	13-Sep
Quadris	11 oz	27-Sep
Previcure Flex	1.2 pt	27-Sep

Table 2. Insecticides Zucchini Squash Cultigen Study 2023, Clayton, NC.		
Product	**Rate per acre**	**Application Date(s)**
Brigade	6.5 oz	11-Aug
Mustang Maxx	2.75 oz	16-Aug, 30-Aug, 20-Sep
Assail 30 WP	5.3 oz	23-Aug, 13-Sep
Perm-Up	8 oz	13-Sep
Agrimek	2.5 oz	27-Sep

Weather

Weather was generally favorable for the duration of the study (Figure 1a and 1b). Temperatures at planting and during growth periods were hot, averaging around 80°F, and decreased steadily through harvests in September. There were some periods of heavy rainfall accompanied by strong winds that resulted in some plants breaking at the base. Approximately 8 inches of rain occurred at the field planting site in Clayton, NC during the growing season (Figure 1b).

Figure 1a. Temperature and Precipitation Pre-Plant for Central Crops Research Station in Clayton, NC

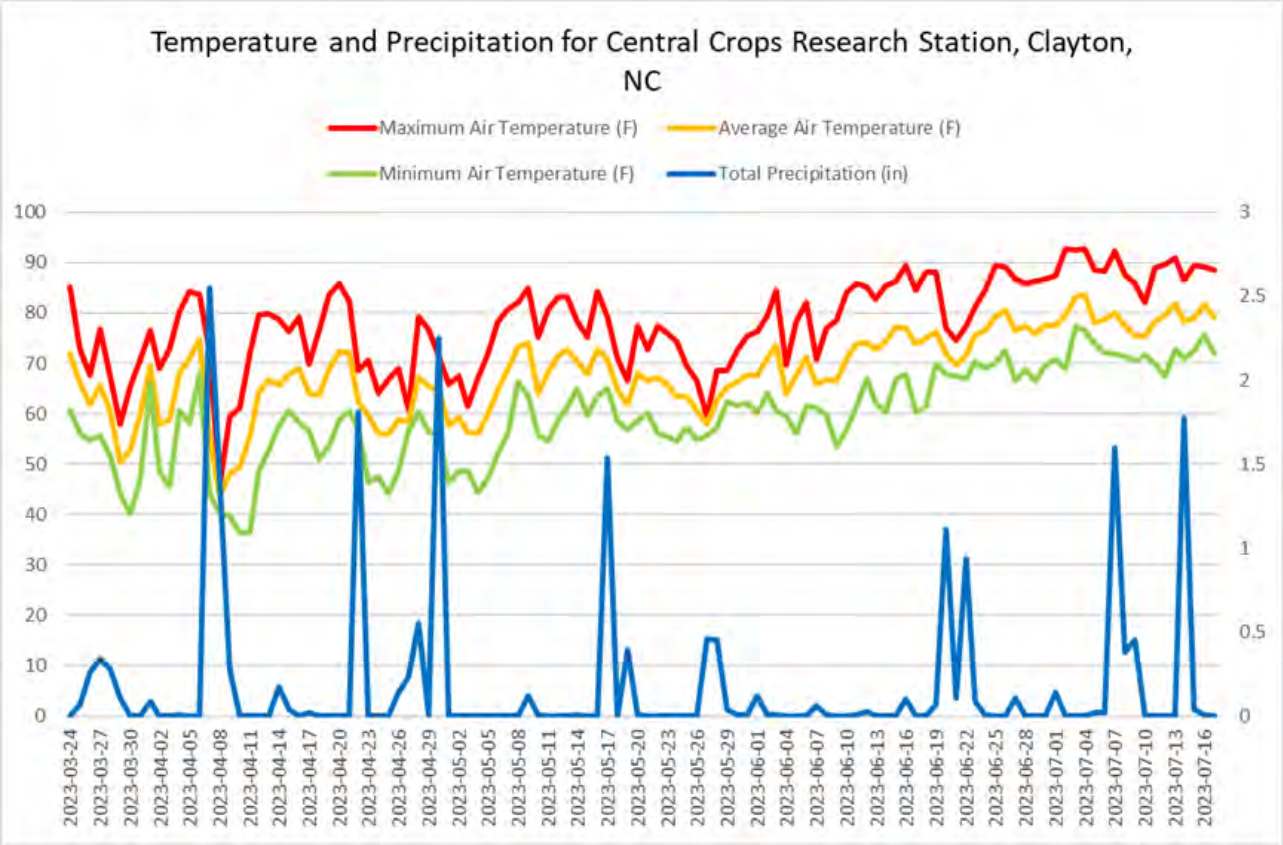
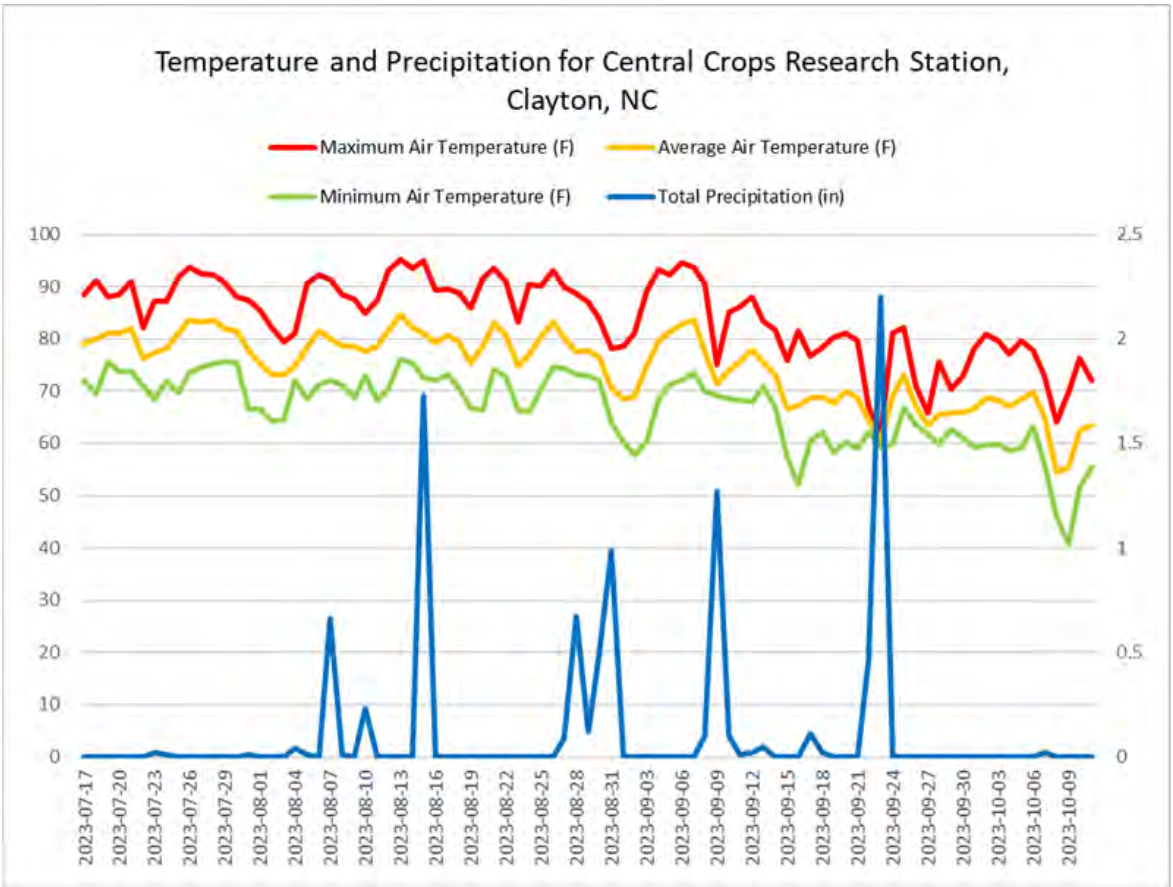


Figure 1b. Temperature and Precipitation Plant to Harvest for Central Crops Research Station, Clayton, NC



Study Design and Data Collection

The study used a randomized complete block design with 4 replications. Harvests were conducted three times per week, beginning on 5 September 2023 and the final harvest occurring on 6 October 2023 for a total of 15 harvests. Fruits were picked when the blossom was detached from the fruit and the fruit reached a sufficient length (4.5 – 5 inches). Fruits were then categorized as marketable 1s, marketable 2s, or non-marketable: Marketable 1s are well-formed, free from decay or damage, fairly young and tender, and has stem attached (USDA); Marketable 2s are slightly off in shape or color but still marketable; Fruit that were small or apparently not pollinated, or were misshapen, were categorized as culls (non-marketable). Virus-symptomatic fruit were categorized separately to assess the progression of virus pressure among the 19 cultigens throughout the growing season. Leaves with virus symptoms were collected by Syngenta and Seminis. Both companies found papaya ring spot to be the only virus present. Graded fruit were weighed and counted for each category and plot. In addition to yield, other quality measurements were taken such as average length and width, plant

canopy, fruit color and speckling, and spine ratings of the plant. After the final harvest, the zucchini plants were rated for powdery mildew susceptibility.

Financial Support

In addition to seed companies, this research was supported by the College of Life and Agricultural Sciences, North Carolina Agriculture Research, the North Carolina Cooperative Extension Services, and the North Carolina Department of Agriculture and Consumer Services. This work was in part supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under award number 2020-51181-32139 (CucCAP).

Results and Discussion

Cumulative Harvests (1-15)

Cumulative Yield: 20 lb boxes/acre and percent by grade

The entry with the highest total marketable yield in 20 lb boxes per acre across all 15 harvests was ‘MG0477’ from Syngenta at 1,669 boxes/ac (Table 3). ‘EXP 3595’ from Bejo and ‘Blade Runner’ from Syngenta ranked second and third at 1,467 boxes/ac and 1,283 boxes/ac, respectively. The average yield in 20 lb boxes per acre across all 19 entries was 826 boxes/ac. ‘SV0782’ and ‘SV0813’ from Seminis and ‘EXP 3641’ from Bejo all yielded well above the average. Virus symptoms on zucchini leaves were readily apparent prior to the first harvest on certain cultigens. Large amounts of virus-symptomatic, and therefore unmarketable, fruit in some cultivars reduced the overall average number of marketable 20 lb boxes per acre. For example, the cultivar ‘Zucchini Elite’ was entered as a check and had no virus resistance. It yielded 894 boxes/ac of virus-symptomatic fruit and only 51 boxes/ac of marketable fruit.

86% of ‘MG0477’ fruit harvested were in the marketable 1 category (Table 3), the highest percentage of marketable 1s out of all 19 entries. Some entries such as ‘Renegade’ from Enza Zaden and ‘SV6198’ from Seminis had high percentages of marketable fruit and low virus incidence, (fourth and fifth for percentage of marketable 1s, respectively), but had lower yields overall (eighth and tenth for total marketable yield). ‘EXP 3595’ had high yields and the lowest virus incidence across all entries and harvests, with 2% of fruit having virus symptoms. ‘SV5432’ from Seminis had the highest incidence of virus, with 99% of fruit across all harvests having virus symptoms.

Table 3. Cumulative yield in 20 lb boxes per acre across all harvests[1] and percent of yield by grade. Zucchini cultigen study, Clayton, NC 2023.												
			Number of 20 lb boxes per acre						Percent of yield by grade			
Cultigen	Company	Rank[2]	Marketable 1s	Marketable 2s	Culls[3]	Virus[4]	Total Mkt.[5]	Group	Marketable 1s	Marketable 2s	Cull	Virus
MG0477	Syngenta	1	1550	120	67	50	1669	A	86	7	4	3
EXP 3595	Bejo	2	1356	111	121	33	1467	AB	83	7	8	2
Blade Runner	Syngenta	3	1198	83	57	61	1283	ABC	85	6	4	4
SV0782	Seminis	4	1021	192	188	206	1212	ABCD	63	12	12	13
SV0813	Seminis	5	995	140	93	38	1138	ABCDE	77	12	7	4
EXP 3641	Bejo	6	970	126	105	120	1094	ABCDE	73	10	9	9
Outlaw	Enza Zaden	7	918	76	88	153	993	BCDEF	73	6	7	14
Renegade	Enza Zaden	8	881	62	77	50	941	BCDEF	82	6	7	5
Fortress	Syngenta	9	745	167	74	506	914	BCDEF	51	11	5	33
SV6198	Seminis	10	819	73	75	53	892	BCDEF	81	7	7	5
Endurance	US AgriSeeds	11	707	142	52	468	849	CDEF	52	11	4	34
Kefren	Rijk Zwaan	12	673	147	27	327	818	CDEF	58	12	2	28
Respect	Clifton (HM Clause)	13	684	84	76	567	768	CDEF	49	6	6	40
Leopard	Clifton (HM Clause)	14	528	55	47	571	583	DEFG	44	5	4	48
Cardea	Seedway	15	432	93	32	732	525	EFG	34	8	3	55
Legend	US AgriSeeds	16	335	74	25	682	408	FG	29	6	2	63
SV5434	Seminis	17	54	11	14	701	64	G	8	1	2	89
Zucchini Elite	Clifton (HM Clause)	18	29	20	5	894	51	G	4	2	1	92
SV5432	Seminis	19	19	4	19	1234	21	G	0	0	1	99
	Average:		732	94	65	392	826		54	7	5	34
	LSD (0.05)[6]:		603	141	128	395	648		28	10	10	30

1. Total of 15 harvests. Harvests 1-5 occurred on 5, 6, 8, 11, and 13 September; Harvests 6-10 occurred on 15, 18, 20, 22, and 25 September; Harvests 11-15 occurred on 27, 29 September, 2, 4, 6 October 2023.

2. Ranked by total marketable yield.

3. Culls consisted primarily of misshaped fruit.

4. Fruit were discolored or rough/disfigured due to virus.

5. Total marketable includes all size categories except culls and virus.

6. Least Significant Difference (LSD) is the minimum difference required between two cultigens for a significant difference in that category at $P < 0.05$.

Cumulative Yield: Number of fruit per plant by grade

The entry with the greatest number of marketable fruit per plant across all 15 harvests was 'MG0477' from Syngenta with 15.1 no/plant (Table 4). 'EXP 3595' from Bejo and 'Blade Runner' from Syngenta ranked second and third for total marketable fruit per plant with 14.4 no/plant and 13.4 no/plant, respectively. The average number of marketable fruit per plant across all 19 cultigens was 8.9 per plant. More than half of the 19 cultigens yielded above this average, which was greatly reduced due to the large number of virus-symptomatic fruit in some cultigens.

Table 4. Number of fruit per plant across all harvests[1]. Zucchini cultigen study, Clayton, NC 2023.

			Fruit number per plant				
Cultigen	**Company**	**Rank[2]**	**Marketable 1s**	**Marketable 2s**	**Culls[3]**	**Virus[4]**	**Total Mkt.[5]**
MG0477	**Syngenta**	**1**	14	1.2	1.4	0.5	15.1
EXP 3595	**Bejo**	**2**	13.2	1.2	1.9	0.4	14.4
Blade Runner	**Syngenta**	**3**	12.4	1	0.9	0.8	13.4
EXP 3641	**Bejo**	**4**	11.5	1.6	2.4	1.3	13.1
SV0813	**Seminis**	**5**	10.7	1.6	1.4	0.4	12.2
SV0782	**Seminis**	**6**	9.9	2	3	1.8	11.9
Outlaw	**Enza Zaden**	**7**	10.7	0.8	1.4	1.9	11.5
SV6198	**Seminis**	**8**	10.5	1	1.7	0.6	11.5
Kefren	**Rijk Zwaan**	**9**	9.5	1.7	0.7	3.9	11.2
Renegade	**Enza Zaden**	**10**	9.8	0.9	1.5	0.5	10.6
Endurance	**US AgriSeeds**	**11**	7.8	1.3	0.8	5.2	9.1
Respect	**Clifton (HM Clause)**	**12**	7.5	0.8	1.2	6.1	8.3
Fortress	**Syngenta**	**13**	6.7	1.5	0.8	4.9	8.2
Leopard	**Clifton (HM Clause)**	**14**	6.3	0.8	0.8	6.5	7.1
Cardea	**Seedway**	**15**	4.5	1	0.7	8.1	5.5
Legend	**US AgriSeeds**	**16**	3.3	0.7	0.4	7.4	4.0
SV5434	**Seminis**	**17**	0.8	0.2	0.4	12	0.9
Zucchini Elite	**Clifton (HM Clause)**	**18**	0.4	0.4	0.1	12.7	0.8
SV5432	**Seminis**	**19**	0.2	0	0	13.3	0.3
		Average:	7.9	1	1.1	4.7	8.9
		LSD (0.05)[6]:	5.6	1.2	2	4.3	5.6

1. Total of 15 harvests. Harvests 1-5 occurred on 5, 6, 8, 11, and 13 September; Harvests 6-10 occurred on 15, 18, 20, 22, and 25 September; Harvests 11-15 occurred on 27, 29 September, 2, 4, 6 October 2023.
2. Ranked by total marketable fruit per plant.
3. Culls consisted primarily of misshaped fruit.
4. Fruit were discolored or rough/disfigured due to virus.
5. Total marketable includes all categories except culls and virus.
6. Least Significant Difference (LSD) is the minimum difference required between two cultigens for a significant difference in that category at $p < 0.05$.

Quality: Fruit quality

Zucchini fruit were evaluated for quality characteristics such as color, speckling, and average length and width. The average color rating across all 19 cultigens was 3.5 on a 1-5 scale, with 1 = pale green and 5 = dark green (Table 5). The greatest difference from this average was 'SV6198' from Seminis, which had a color rating of 4.5. The average speckling rating across all 19 cultigens was 2.0 on a scale of 1-5, with 1 = no speckling and 5 = heavy speckling. The most speckled cultigens were 'Leopard' from Clifton (HM Clause) at 3.6 and 'EXP 3595' from Bejo at 3.3. The average LD ratio across all 19 cultigens was 3.8.

Table 5. Fruit quality. Zucchini cultigen study, Clayton, NC 2023.

Cultigen	Company	Fruit Color[1]	Speckling[2]	Avg Length[3]	Avg Width	LD[4]
Blade Runner	Syngenta	3.8	1.8	17.6	4.5	4.0
Cardea	Seedway	3.8	1.6	17.6	4.7	3.8
Endurance	US AgriSeeds	3.1	1.3	17.6	4.6	3.9
EXP 3595	Bejo	3.1	3.3	19.1	4.4	4.4
EXP 3641	Bejo	2.9	2.9	18.4	4.7	4.0
Fortress	Syngenta	3.3	1.6	16.9	4.5	3.8
MG0477	Syngenta	3.5	1.8	18.3	4.9	3.8
Kefren	Rijk Zwaan	3.6	2	16.7	4.6	3.7
Legend	US AgriSeeds	3.2	2.6	18.0	4.9	3.7
Leopard	Clifton (HM Clause)	3	3.6	17.3	4.8	3.7
Outlaw	Enza Zaden	3.6	1.4	17.5	4.7	3.7
Renegade	Enza Zaden	3.5	1.5	18.2	4.7	3.9
Respect	Clifton (HM Clause)	3.9	2.6	17.2	4.7	3.7
SV0782	Seminis	3.5	1.9	17.8	4.3	4.2
SV0813	Seminis	3.4	2	17.3	4.4	3.9
SV5432	Seminis	3.8	0.9	15.3	4.7	3.3
SV5434	Seminis	3.5	1.6	15.6	4.6	3.4
SV6198	Seminis	4.5	1.6	17.4	4.7	3.8
Zucchini Elite[5]	Clifton (HM Clause)	.	.	15.5	4.7	3.3
	Average	3.5	2	17.3	4.6	3.8
	LSD (0.05)[6]:	0.4	0.7	1.7	0.5	0.2

1. Color ratings were taken on 18 September and are on a scale of 1-5; 1 = pale green, 5 = dark green.
2. Speckling ratings were taken on 18 September and are on a scale of 1-5; 1 = no speckling, 5 = heavy speckling.
3. Length and width measurements were taken on 15 and 22 September, based on an average of 5 fruits.
4. LD is the ratio of the fruit length and width.
5. Excluded from color and speckling ratings due to no fruit without virus.
6. Least Significant Difference (LSD) is the minimum difference required between two cultigens for a significant difference in that category at $P < 0.05$.

Quality: Plant quality

Zucchini plants were evaluated for quality characteristics such as spininess, canopy, and powdery mildew severity. The average spininess rating across all 19 cultigens was 4.3 on a 1-10 scale, with 1 = no spines and 10 = many coarse spines (Table 6). The entry with the highest spininess rating was 'Zucchini Elite' from Clifton (HM Clause) at 7.8, and the entry with the lowest spininess rating was 'Legend' from US AgriSeeds at 1.0. The average canopy rating across all 19 entries was 4.2 on a 1-10 scale, with 1 = open and 10 = dense. The entries with the most open canopies were 'SV6198' from Seminis at 1.0 and 'Renegade' from Enza Zaden at 2.1.

Plants were rated for powdery mildew severity on 11 October 2023, following the last harvests. The average powdery mildew rating across all 19 cultigens was 5.2 on a scale of 1-9, with 1 = none and 9 = very high. The entries with the lowest powdery mildew ratings were 'Outlaw' from Enza Zaden and 'SV5432' from Seminis at 2.5 for both entries.

Table 6. Plant quality. Zucchini cultigen study, Clayton, NC 2023.

Cultigen	Company	Spininess[1]	Canopy[2]	Powdery Mildew[3]
Blade Runner	**Syngenta**	3.7	2.8	3.3
Cardea	**Seedway**	3.2	2.8	4.8
Endurance	**US AgriSeeds**	4	4.9	4.3
EXP 3595	**Bejo**	4	3.4	6.8
EXP 3641	**Bejo**	2.2	4.1	5.5
Fortress	**Syngenta**	4.7	5.0	4.8
MG0477	**Syngenta**	3	4.0	5.3
Kefren	**Rijk Zwaan**	2.5	2.8	3.3
Legend	**US AgriSeeds**	1	4.5	6.8
Leopard	**Clifton (HM Clause)**	6.2	5.7	7
Outlaw	**Enza Zaden**	2.2	2.8	2.5
Renegade	**Enza Zaden**	2	2.1	4.3
Respect	**Clifton (HM Clause)**	3.2	6.8	7.3
SV0782	**Seminis**	7	4.5	6.3
SV0813	**Seminis**	6.5	4.3	6
SV5432	**Seminis**	5.5	5.9	2.5
SV5434	**Seminis**	6.7	5.0	4.8
SV6198	**Seminis**	5.5	1.0	5.3
Zucchini Elite	**Clifton (HM Clause)**	7.8	6.8	8
	Average:	4.3	4.2	5.2
	LSD (0.05)[4]:	0.8	1.4	1.8

1. Spine ratings for plant stem and foliage were taken 22 September and are on a scale of 1-10; 1 = no spines, 10 = coarse and many spines.
2. Canopy ratings were taken on 11 and 22 September and are on a scale of 1-10; 1 = open, 10 = dense. The two ratings were averaged.
3. Powdery Mildew ratings for disease severity were taken on 11 October and are on a scale of 1-9; 1 = none, 3 = low, 5 = moderate, 7 = high, 9 = very high.
4. Least Significant Difference (LSD) is the minimum difference required between two cultigens for a significant difference in that category at $P < 0.05$.

Early Harvests (1-5): September 5, 6, 8, 11, 13

Yield: 20 lb boxes/acre for the early harvests

For the early harvests (1-5), 'SV0782' from Seminis had the highest total marketable yield in 20 lb boxes per ac at 489 boxes/ac (Table 7). 'MG0477' from Syngenta and 'EXP 3595' from Bejo ranked second and third at 480 boxes/ac and 428 boxes/ac, respectively, for the early harvests. The average total marketable yield for the early harvests was 296 boxes/ac.

Ten cultigens yielded virus-symptomatic fruit for the early harvests. The average yield of symptomatic fruit across those 10 cultigens was 72 boxes/ac (Table 7). Four cultigens yielded above the average number of boxes of virus-symptomatic fruit per acre: 'Zucchini Elite' from Clifton (HM Clause), 'SV5432' and 'SV5434' from Seminis, and 'Legend' from US AgriSeeds.

Table 7. Yield in 20 lb boxes per acre for the early harvests (1-5)[1]. Zucchini cultigen study, Clayton, NC 2023.

			Number of 20 lb boxes per acre				
Cultigen	Company	Rank[2]	Marketable 1s	Marketable 2s	Culls[3]	Virus[4]	Total Mkt.[5]
SV0782	Seminis	1	459	31	33	6	489
MG0477	Syngenta	2	453	27	15	0	480
EXP 3595	Bejo	3	413	15	36	0	428
Endurance	US AgriSeeds	4	336	40	25	9	376
Blade Runner	Syngenta	5	360	11	7	0	372
Respect	Clifton (HM Clause)	6	348	16	27	0	364
SV0813	Seminis	7	320	37	11	0	358
EXP 3641	Bejo	8	314	34	25	0	349
Fortress	Syngenta	9	313	31	23	4	345
Renegade	Enza Zaden	10	321	9	10	0	331
Kefren	Rijk Zwaan	11	285	39	11	11	325
Outlaw	Enza Zaden	12	302	9	21	0	310
SV6198	Seminis	13	279	21	7	0	300
Leopard	Clifton (HM Clause)	14	271	26	30	22	297
Cardea	Seedway	15	221	22	14	72	243
Legend	US AgriSeeds	16	151	19	20	127	169
Zucchini Elite	Clifton (HM Clause)	17	31	15	2	156	48
SV5434	Seminis	18	28	9	1	135	37
SV5432	Seminis	19	9	4	0	175	12
	Average:		274	22	18	72	296
	LSD (0.05)[6]:		235	47	49	90	242

1. Early harvests (1-5) occurred on 5, 6, 8, 11, and 13 September 2023.
2. Ranked by total marketable yield in 20 lb boxes per acre.
3. Culls consisted primarily of misshaped fruit.
4. Fruit were discolored or rough/disfigured due to virus.
5. Total marketable includes all categories except culls and virus.
6. Least Significant Difference (LSD) is the minimum difference required between two cultigens for a significant difference in that category at $P < 0.05$.

Yield: Number of fruit per plant for the early harvests

The entries with the greatest number of marketable fruit per plant for the early harvests (1-5) were 'MG0477' from Syngenta and 'SV0782' from Seminis at 5.5 no/plant for both entries (Table 8). 'EXP 3595' from Bejo and 'Kefren' from Rijk Zwaan ranked second and third for total marketable yield per plant in the early harvests at 5.2 no/plant and 5.1 no/plant, respectively. The average number of marketable fruit per plant for the early harvests was 3.7 no/plant.

While half of the entries had some incidence of virus-symptomatic fruit for the early harvests, it had little impact on the number of marketable fruit per plant for most cultigens. Only four cultigens had greater than 1.0 virus-symptomatic fruit per plant for the early harvests (Table 8).

Table 8. Number of fruit per plant for the early harvests (1-5)[1]. Zucchini cultigen study, Clayton, NC 2023.

			Number of fruit per plant				
Cultigen	**Company**	**Rank[2]**	**Marketable 1s**	**Marketable 2s**	**Culls[3]**	**Virus[4]**	**Total Mkt.[5]**
MG0477	**Syngenta**	**1**	5.2	0.4	0.3	0	5.5
SV0782	**Seminis**	**1**	5	0.5	0.7	0.1	5.5
EXP 3595	**Bejo**	**2**	4.9	0.3	0.5	0	5.2
Kefren	**Rijk Zwaan**	**3**	4.7	0.4	0.2	0.2	5.1
Endurance	**US AgriSeeds**	**4**	4.6	0.3	0.5	0.1	4.9
Respect	**Clifton (HM Clause)**	**5**	4.4	0.3	0.4	0	4.7
EXP 3641	**Bejo**	**6**	4.1	0.5	0.6	0	4.6
SV6198	**Seminis**	**6**	4.3	0.3	0.2	0	4.6
Outlaw	**Enza Zaden**	**7**	4	0.1	0.3	0	4.2
Renegade	**Enza Zaden**	**7**	4	0.1	0.2	0	4.2
SV0813	**Seminis**	**7**	3.8	0.4	0.1	0	4.2
Blade Runner	**Syngenta**	**8**	3.9	0.2	0.1	0	4.1
Leopard	**Clifton (HM Clause)**	**8**	3.7	0.4	0.5	0.3	4.1
Fortress	**Syngenta**	**9**	3.2	0.3	0.3	0.1	3.5
Cardea	**Seedway**	**10**	2.6	0.4	0.3	0.9	3
Legend	**US AgriSeeds**	**11**	1.7	0.2	0.3	1.4	1.9
Zucchini Elite	**Clifton (HM Clause)**	**12**	0.4	0.3	0	2.8	0.8
SV5434	**Seminis**	**13**	0.5	0.1	0	2.7	0.6
SV5432	**Seminis**	**14**	0.1	0.1	0	2.9	0.2
	Average:		3.4	0.3	0.3	1.2	3.7
	LSD (0.05)[6]:		5.6	0.5	0.7	1.2	2.5

1. Early harvests (1-5) occurred on 5, 6, 8, 11, and 13 September 2023.
2. Ranked by total marketable yield in 20 lb boxes per acre.
3. Culls consisted primarily of misshaped fruit.
4. Fruit were discolored or rough/disfigured due to virus.
5. Total marketable includes all categories except culls and virus.
6. Least Significant Difference (LSD) is the minimum difference required between two cultigens for a significant difference in that category at $P < 0.05$.

Mid-season Harvests (6-10): September 15, 18, 20, 22, 25

Yield: 20 lb boxes/acre for the mid-season harvests

For the mid-season harvests (6-10), 'MG0477' from Syngenta had the highest total marketable yield in 20 lb boxes per acre at 715 boxes/ac (Table 9). 'EXP 3595' from Bejo and 'Blade Runner' from Syngenta ranked second and third at 608 boxes/ac and 537 boxes/ac, respectively, for the mid-season harvests. The average total marketable yield for the mid-season harvests was 330 boxes/ac.

Virus pressure increased with higher temperatures and more favorable conditions for insect vectors for the mid-season harvests. Five additional cultigens yielded virus-symptomatic fruit for the mid-season harvests, but not for the early harvests: 'Respect' from Clifton (HM Clause), 'SV6198' from Seminis, 'EXP 3641' from Bejo, 'Outlaw' from Enza Zaden, and 'MG0477' from Syngenta. A total of 15 cultigens out of 19 total yielded some virus-symptomatic fruit for the mid-season harvests, averaging 200 boxes of symptomatic fruit per acre (Table 9).

Table 9. Yield in 20 lb boxes per acre for the mid-season harvests (6-10)[1]. Zucchini cultigen study, Clayton, NC 2023.

			Number of 20 lb boxes per acre				
Cultigen	Company	Rank[2]	Marketable 1s	Marketable 2s	Culls[3]	Virus[4]	Total Mkt.[5]
MG0477	Syngenta	1	675	40	23	4	715
EXP 3595	Bejo	2	567	41	45	0	608
Blade Runner	Syngenta	3	513	23	28	0	537
SV0813	Seminis	4	380	65	37	0	446
SV0782	Seminis	5	369	68	80	85	438
Outlaw	Enza Zaden	6	398	21	31	7	418
Fortress	Syngenta	7	337	68	23	167	406
EXP 3641	Bejo	8	355	45	48	18	400
SV6198	Seminis	9	357	21	27	33	378
Renegade	Enza Zaden	10	331	14	18	0	344
Endurance	US AgriSeeds	11	276	43	17	170	319
Respect	Clifton (HM Clause)	12	289	29	23	262	317
Kefren	Rijk Zwaan	13	234	75	9	106	309
Cardea	Seedway	14	190	64	8	324	254
Leopard	Clifton (HM Clause)	15	186	16	17	223	202
Legend	US AgriSeeds	16	155	15	3	246	170
SV5432	Seminis	17	8	0	20	537	8
SV5434	Seminis	18	3	2	16	314	4
Zucchini Elite	Clifton (HM Clause)	19	0	5	0	497	3
		Average:	312	36	26	200	330
		LSD (0.05)[6]:	299	81	62	224	306

1. Mid-season harvests (6-10) occurred on 15, 18, 20, 22, and 25 September 2023.
2. Ranked by total marketable yield in 20 lb boxes per acre.
3. Culls consisted primarily of misshaped fruit.
4. Fruit were discolored or rough/disfigured due to virus.
5. Total marketable includes all categories except culls and virus.
6. Least Significant Difference (LSD) is the minimum difference required between two cultigens for a significant difference in that category at $P < 0.05$.

Yield: Number of fruit per plant for the mid-season harvests

For the mid-season harvests (6-10), 'MG0477' and 'Blade Runner' from Syngenta had the greatest numbers of marketable fruit per plant at 6.0 and 5.9, respectively (Table 10). 'EXP 3595' from Bejo and 'SV0813' from Seminis ranked third and fourth at 5.4 and 4.8, respectively. These four cultigens also had no virus-symptomatic fruit for the early or mid-season harvests, along with 'Renegade' from Enza Zaden. The average number of marketable fruit per plant for the mid-season harvests was 3.3.

Virus incidence and severity began to have a large impact on the number of marketable fruit for several cultigens for the mid-season harvests. Six cultigens yielded more virus-symptomatic fruit than marketable fruit per plant, and the check entry 'Zucchini Elite' yielded the greatest amount of any grade of fruit per plant at 6.7 no/plant of virus-symptomatic fruit for the mid-season harvests (Table 10).

Table 10. Number of fruit per plant for the mid-season harvests (6-10)[1]. Zucchini cultigen study, Clayton, NC 2023.

			Number of fruit per plant				
Cultigen	**Company**	**Rank[2]**	**Marketable 1s**	**Marketable 2s**	**Culls[3]**	**Virus[4]**	**Total Mkt.[5]**
MG0477	**Syngenta**	**1**	5.5	0.5	0.5	0	6
Blade Runner	**Syngenta**	**2**	5.5	0.4	0.4	0	5.9
EXP 3595	**Bejo**	**3**	5.1	0.3	0.7	0	5.4
SV0813	**Seminis**	**4**	4.1	0.7	0.5	0	4.8
Outlaw	**Enza Zaden**	**5**	4.4	0.3	0.5	0.1	4.7
EXP 3641	**Bejo**	**6**	4	0.6	0.9	0.2	4.6
SV6198	**Seminis**	**7**	4.2	0.2	0.6	0.3	4.4
SV0782	**Seminis**	**8**	3.3	0.7	1.3	0.8	4
Kefren	**Rijk Zwaan**	**9**	3.1	0.8	0.2	1.4	3.8
Renegade	**Enza Zaden**	**10**	3.6	0.2	0.6	0	3.7
Fortress	**Syngenta**	**11**	2.6	0.6	0.2	1.7	3.2
Endurance	**US AgriSeeds**	**12**	2.5	0.5	0.2	2	3
Respect	**Clifton (HM Clause)**	**12**	2.7	0.3	0.4	2.8	3
Cardea	**Seedway**	**13**	1.7	0.6	0.2	3.5	2.3
Leopard	**Clifton (HM Clause)**	**14**	2	0.2	0.3	2.6	2.2
Legend	**US AgriSeeds**	**15**	1.2	0.2	0.1	2.6	1.4
SV5432	**Seminis**	**16**	0.1	0	0	5.3	0.1
SV5434	**Seminis**	**16**	0.1	0	0.3	5.1	0.1
Zucchini Elite	**Clifton (HM Clause)**	**16**	0	0.1	0	6.7	0.1
		Average:	3.1	0.4	0.4	2.5	3.3
		LSD (0.05)[6]:	2.5	0.7	1	2.5	2.3

1. Mid-season harvests (6-10) occurred on 15, 18, 20, 22, and 25 September 2023.
2. Ranked by total marketable yield in 20 lb boxes per acre.
3. Culls consisted primarily of misshaped fruit.
4. Fruit were discolored or rough/disfigured due to virus.
5. Total marketable includes all categories except culls and virus.
6. Least Significant Difference (LSD) is the minimum difference required between two cultigens for a significant difference in that category at $P < 0.05$.

Late Harvests (11-15): September 27, 29; October 2, 4, 6

Yield: 20 lb boxes/acre for the late harvests

For the late harvests (11-15), 'MG0477' from Syngenta had the highest total marketable yield in 20 lb boxes per acre at 475 boxes/ac (Table 11). 'EXP 3595' from Bejo and 'Blade Runner' from Syngenta ranked second and third at 431 boxes/ac and 373 boxes/ac, respectively, for the late harvests. The average total marketable yield for the late harvests was 222 boxes/ac.

All 19 entries yielded some virus-symptomatic fruit for the late harvests. Four cultigens yielded virus-symptomatic fruit only in the late harvests: 'Blade Runner' from Syngenta, 'EXP 3595' from Bejo, 'Renegade' from Enza Zaden, and 'SV0813' from Seminis.

Table 11. Yield in 20 lb boxes per acre for the late harvests (11-15)[1]. Zucchini cultigen study, Clayton, NC 2023.

			Number of 20 lb boxes per acre				
Cultigen	Company	Rank[2]	Marketable 1s	Marketable 2s	Culls[3]	Virus[4]	Total Mkt.[5]
MG0477	Syngenta	1	423	52	29	46	475
EXP 3595	Bejo	2	376	55	41	33	431
Blade Runner	Syngenta	3	324	49	23	65	373
EXP 3641	Bejo	4	298	47	33	98	345
SV0813	Seminis	5	296	39	46	45	334
SV0782	Seminis	6	191	93	76	119	284
Renegade	Enza Zaden	7	227	39	50	37	266
Outlaw	Enza Zaden	8	218	46	37	145	265
SV6198	Seminis	9	183	32	41	20	215
Kefren	Rijk Zwaan	10	151	33	7	215	184
Fortress	Syngenta	11	94	68	29	332	163
Endurance	US AgriSeeds	12	96	59	9	289	155
Respect	Clifton (HM Clause)	13	48	39	26	304	87
Leopard	Clifton (HM Clause)	14	71	13	0	327	84
Legend	US AgriSeeds	15	29	40	2	309	69
Cardea	Seedway	16	21	7	10	335	28
SV5434	Seminis	17	22	0	0	255	22
SV5432	Seminis	18	0	0	0	526	0
Zucchini Elite	Clifton (HM Clause)	18	0	0	0	238	0
	Average:		180	44	31	197	222
	LSD (0.05)[6]:		233	99	75	209	248

1. Late harvests (11-15) occurred on 27, 29 September, 2, 4, 6 October 2023.
2. Ranked by total marketable yield in 20 lb boxes per acre.
3. Culls consisted primarily of misshaped fruit.
4. Fruit were discolored or rough/disfigured due to virus.
5. Total marketable includes all categories except culls and virus.
6. Least Significant Difference (LSD) is the minimum difference required between two cultigens for a significant difference in that category at $P < 0.05$.

Yield: Number of fruit per plant for the late harvests

The entry with the greatest number of marketable fruit per plant for the late harvests was 'EXP 3641' from Bejo at 3.9 no/plant (Table 12). 'EXP 3595' from Bejo and 'MG0477' from Syngenta ranked second at 3.7 no/plant for both entries. The average number of marketable fruit per plant for the late harvests was 2.1 no/plant. This average decreased as the season went on primarily due to increased virus pressure that therefore resulted in large numbers of virus-symptomatic fruit per plant in later harvests.

All cultigens had some degree of virus incidence by the late harvests, which took place in late September and early October. 'EXP 3641', which ranked first for marketable fruit per plant, also yielded 1.1 no/plant of virus symptomatic fruit – more than any other cultigen ranked in the top five for total marketable yield (Table 12).

Table 12. Number of fruit per plant for the late harvests (11-15)[1]. Zucchini cultigen study, Clayton, NC 2023.

			Number of fruit per plant				
Cultigen	Company	Rank[2]	Marketable 1s	Marketable 2s	Culls[3]	Virus[4]	Total Mkt.[5]
EXP 3641	Bejo	1	3.4	0.5	0.8	1.1	3.9
EXP 3595	Bejo	2	3.2	0.5	0.7	0.4	3.7
MG0477	Syngenta	2	3.3	0.4	0.6	0.5	3.7
Blade Runner	Syngenta	3	3	0.5	0.4	0.8	3.4
SV0813	Seminis	4	2.8	0.5	0.7	0.5	3.3
Renegade	Enza Zaden	5	2.2	0.5	0.8	0.4	2.7
Outlaw	Enza Zaden	6	2.3	0.3	0.6	1.8	2.6
SV0782	Seminis	7	1.7	0.8	1	0.9	2.5
SV6198	Seminis	7	2.1	0.4	0.9	0.3	2.5
Kefren	Rijk Zwaan	8	1.7	0.5	0.2	2.5	2.2
Fortress	Syngenta	9	0.9	0.6	0.3	3.1	1.5
Endurance	US AgriSeeds	10	0.7	0.5	0.2	3.1	1.2
Leopard	Clifton (HM Clause)	11	0.6	0.2	0	3.7	0.8
Legend	US AgriSeeds	12	0.3	0.4	0.1	3.3	0.7
Respect	Clifton (HM Clause)	12	0.5	0.2	0.4	3.3	0.7
Cardea	Seedway	13	0.2	0.1	0.2	3.8	0.3
SV5434	Seminis	14	0.2	0	0	4.2	0.2
SV5432	Seminis	15	0	0	0	5.2	0
Zucchini Elite	Clifton (HM Clause)	15	0	0	0	3.2	0
		Average:	1.7	0.4	0.5	2.2	2.1
		LSD (0.05)[6]:	2.1	0.7	1.1	2	2.1

1. Late harvests (11-15) occurred on 27, 29 September, 2, 4, 6 October 2023.
2. Ranked by total marketable yield in 20 lb boxes per acre.
3. Culls consisted primarily of misshaped fruit.
4. Fruit were discolored or rough/disfigured due to virus.
5. Total marketable includes all categories except culls and virus.
6. Least Significant Difference (LSD) is the minimum difference required between two cultigens for a significant difference in that category at $p < 0.05$.

Percentages by grade and harvest

Virus pressure was minimal for the early harvests and increased throughout the growing season as environmental factors became more hospitable for insect vectors and disease progression. For example, in the cultivar 'Respect', entered as a check because it is commonly grown in North Carolina, 88% of fruit harvested for the early harvests were in the marketable 1s category (Table 13). For the mid-season harvests, only 48% of fruit were marketable 1s, and by the late harvests, only 12% of fruit were in the marketable 1s category.

Table 13. Percentage marketable, cull, and virus symptomatic fruit per indicated harvests[1]. Zucchini cultigen study, Clayton, NC 2023.

		Percentage (%) of yield based on grade											
		Harvests 1-5				Harvests 6-10				Harvests 11-15			
Cultigen	Company	Mkt. 1s	Mkt. 2s	Culls[2]	Virus[3]	Mkt. 1s	Mkt. 2s	Culls	Virus	Mkt. 1s	Mkt. 2s	Culls	Virus
Blade Runner	Syngenta	97	3	1	0	90	4	5	0	67	12	7	13
Cardea	Seedway	66	7	4	24	33	12	1	53	8	2	4	86
Endurance	US AgriSeeds	89	3	8	0	87	6	7	0	73	11	10	6
EXP 3595	Bejo	83	10	7	0	74	11	12	3	63	10	7	20
EXP 3641	Bejo	82	10	6	2	55	9	3	33	22	13	2	63
Fortress	Syngenta	83	9	6	1	56	12	3	28	19	12	6	62
MG0477	Syngenta	91	6	3	0	90	6	4	1	77	9	6	9
Kefren	Rijk Zwaan	84	12	3	3	56	18	2	25	38	8	2	53
Legend	US AgriSeeds	44	5	5	45	34	4	1	61	9	9	1	82
Leopard	Clifton (HM Clause)	77	8	8	8	40	4	4	52	16	4	0	80
Outlaw	Enza Zaden	90	5	6	0	87	4	7	2	48	9	9	35
Renegade	Enza Zaden	93	3	3	0	90	4	5	0	64	11	14	11
Respect	Clifton (HM Clause)	88	4	8	0	48	5	4	43	12	8	8	73
SV0782	Seminis	87	6	6	3	61	12	14	15	41	20	16	24
SV0813	Seminis	85	13	3	0	76	14	8	0	69	9	10	11
SV5432	Seminis	5	2	0	95	1	0	3	98	0	0	0	100
SV5434	Seminis	21	5	1	75	1	1	5	94	7	0	0	94
SV6198	Seminis	92	6	2	0	83	5	6	6	66	11	16	8
Zucchini Elite	Clifton (HM Clause)	14	8	1	76	1	1	0	97	0	0	0	97
	Average:	72	6	5	33	56	7	5	41	41	10	8	49
	LSD (0.05)[4]:	32	13	12	40	36	17	13	39	37	19	20	34

1. Total of 15 harvests. Harvests 1-5 occurred on 5, 6, 8, 11, and 13 September; Harvests 6-10 occurred on 15, 18, 20, 22, and 25 September; Harvests 11-15 occurred on 27, 29 September, 2, 4, 6 October 2023.

2. Culls consisted primarily of misshaped fruit.

3. Fruit were discolored or rough/disfigured due to virus.

4. Least Significant Difference (LSD) is the minimum difference required between two cultigens for a significant difference in that category at $P < 0.05$.

Figure 2. Photo of ‘Blade Runner’ from Syngenta.

Figure 3. Photo of ‘Cardea’ from Seedway.

Figure 4. Photo of ‘Endurance’ from US AgriSeeds.

Figure 5. Photo of ‘EXP 3595’ from Bejo.

Figure 6. Photo of ‘EXP 3641’ from Bejo.

Figure 7. Photo of ‘Fortress’ from Syngenta.

Figure 8. Photo of ‘MG0477’ from Syngenta.

Figure 9. Photo of ‘Kefren’ from Rijk Zwaan.

Figure 10. Photo of ‘Legend’ from US AgriSeeds.

Figure 11. Photo of ‘Leopard’ from Clifton (HM Clause).

Figure 12. Photo of ‘Outlaw’ from Enza Zaden.

Figure 13. Photo of ‘Renegade’ from Enza Zaden.

Figure 14. Photo of ‘Respect’ from Clifton (HM Clause).

Figure 15. Photo of ‘SV0782’ from Seminis.

Figure 16. Photo of ‘SV0813’ from Seminis.

Figure 17. Photo of ‘SV5432’ from Seminis.

Figure 18. Photo of ‘SV5434’ from Seminis.

Figure 19. Photo of ‘SV6198’ from Seminis.

Figure 20. Photo of ‘Zucchini Elite’ from Clifton (HM Clause).