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Maximum Potential Vegetative and Floral Production and Fruit Characteristics of Watermelon Pollenizers

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Abstract. **Triploid (seedless) watermelon [*Citrullus lanatus* (Thunb.) Matsum. and Nak.] pollen is nonviable; thus, diploid (pollenizer) watermelon cultigens are required to supply viable pollen for triploid watermelon fruit set. The objective of this research was to characterize maximum potential vegetative growth, staminate and pistillate flower production over time, and measure exterior and interior fruit characteristics of pollenizer cultigens. Sixteen commercially available and numbered line (hereafter collectively referred to as cultigens) pollenizer and two triploid cultigens were evaluated in 2005 and 2006 at Clayton, NC. Vegetative growth was measured using vine and internode length, and staminate and pistillate flower development was counted weekly. Fruit quality and quantity were determined by measuring individual fruit weights, soluble solids, and rind thickness. Based on vegetative growth, pollenizer cultigens were placed into two distinct groups. Pollenizers, which produced a compact or dwarf plant were 'Companion', 'Sidekick', 'TP91', 'TPS92', and 'WC5108-1216'. Pollenizers having a standard vine length were 'Jenny', 'High Set 11', 'Mickylee', 'Minipol', 'Pinnacle', 'Summer Flavor 800' ('SF800'), 'Super Pollenizer 1' ('SP1'), and 'WH6818'. Cultigens with compact growth habit had shorter internodes and vine lengths compared with the cultigens with standard growth habit. Cultigens with the greatest quantity of staminate flower production through the entire season were 'Sidekick' and 'SP1'. The lowest number of staminate flowers was produced by 'TP91' and 'TPS92'. Based on fruit quality characteristics and production, pollenizers currently or possibly marketed for consumption include 'Mickylee', 'SF800', 'Minipol', 'Jenny', and 'Pinnacle'. The remaining cultigens evaluated in this study should be used strictly as pollenizers based on fruit quality. Arrangement of diploid pollenizers in a commercial planting of triploid watermelons is an important consideration depending on plant vegetative development. Based on staminate flower production, cultigens with higher staminate flower production are potentially superior pollenizers and may lead to improved triploid quality and production. Furthermore, pollenizer selection by fruit characteristics should include a rind pattern easily distinguished from triploid fruit in the field.**

Watermelon production in the United States was 38 million pounds in 2005 [U.S. Department of Agriculture (USDA), National Agricultural Statistics Service, 2006]. Triploid (seedless) watermelons were introduced to the United States in 1951 (Kihara, 1951); and in 2005, three-fourths of the United States' watermelon production was devoted to triploid cultivars (USDA, Economic Research Service, 2005).

In triploid watermelon production, diploids are included as a viable pollen source for pollination and fruit set (Kihara, 1951; Rubatzky and Yamaguchi, 1997). To provide sufficient pollen for maximum triploid fruit yield, plants should be planted in a ratio of one pollenizer plant for every two to four triploid plants (Fiacchino and Walters, 2003; Maynard and Elmstrom, 1992; NeSmith and Duval, 2001). The pollenizer cultivar has an effect on the yield of triploid fruit (Fiacchino and Walters, 2003; Freeman et al., 2007b).

Triploid plants and pollenizers can be planted in separate rows or interplanted in the same row (Maynard and Elmstrom, 1992). The separate row planting method establishes one row of pollenizers and then two to four rows of triploids (Maynard and Elmstrom, 1992; Rubatzky and Yamaguchi, 1997). NeSmith and Duval (2001) reported a decrease in yield when the pollenizer 'Ferarri' was planted more than 6 m from the triploid 'Genesis' indicating that field arrangement of the pollenizer is an important consideration. Planting a pollenizer in the same row to reduce the distance between pollenizer and triploid plant can be done by planting the pollenizer in between two to three triploid plants (interplanted) or by planting a pollenizer in every third or fourth hill that would normally be occupied by a triploid plant. Planting in the same row adds complexity to the planting and harvesting of the crop (Maynard and Elmstrom, 1992). Pollenizer fruit should have a different rind pattern from the triploid so it can be separated and marketed properly (Kihara, 1951; Maynard and Elmstrom, 1992).

The objective of this research was to characterize and quantify the growth and development of diploid watermelon pollenizers, especially recently bred pollenizers developed exclusively for triploid watermelon production (dedicated pollenizers). The vine and internode length were measured because plant competition and suitability of different planting arrangement for pollenizers need to be considered when planted with triploid plants. Determining number of flowers gives an understanding of potential pollen produced from the various pollenizers for fruit set on triploid watermelons. Counting fruit, quantifying harvestable fruit and size, measuring fruit qualities, and observing rind pattern provides information as to which pollenizers could be sold as seeded fruit as well as these that are more suitable for production with specific triploid cultivars.

Materials and Methods

Treatments. Thirteen pollenizer cultigens were evaluated: 'Companion', 'Jenny', 'High Set 11', 'Mickylee', 'Minipol', 'Pinnacle', 'Summer Flavor 800' ('SF800'), 'Super Pollenizer 1' ('SP1'), 'Sidekick', 'TP91', 'TPS92', 'WC5108-1216', and 'WH6818'. Triploid watermelon cultigens, 'Petite Perfection' and 'Tri-X-313', were included for comparison of vegetative and floral habit.

Cultural practices. Seeds were sown into 3.8 cm × 3.8-cm cell trays on 20 Apr. each year. Plants were grown in the greenhouse for 2 weeks and moved to a coldframe for 2 weeks of conditioning for field establishment. Seedlings were hand planted into beds covered with black polyethylene mulch at the Central Crops Research Station, Clayton, NC, into a Norfolk loamy sand (fine-loamy, kaolinitic, thermic typic Kandiudults) soil on 24 May 2005 and 17 May 2006. As beds were formed and just before mulch was laid, the soil was fumigated with 1,3-dichloropropene and chloropicrin (Telone C-35: Dow AgroSciences, Calgary, Alberta, Canada) and broadcast-fertilized (0N–0P–50K at 149.1 $kg \cdot ha^{-1}$ and 16N–0P–0K at 213.0 $kg \cdot ha^{-1}$) according to soil test recommendations. In-row spacing was 1.3 m and between-row spacing was 3.1 m. Plant spacing around plants was maximized to facilitate individual plant measurements. Four watermelon plants of each cultigen were included in each plot. Cultigens were arranged in a randomized complete block design with five replications. Pesticides and fertigation were applied based on North Carolina cultural recommendations (Sanders, 2004, 2005).

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Vegetative development. Vine and internode lengths were measured at 4 and 5 weeks after transplanting (WAT). The longest vine on each plant was measured to the nearest 0.5 cm from the crown to the tip of the vine. The internode measurement to the nearest 0.5 cm was taken from the internode between the third and fourth fully expanded leaves from the tip of the longest vine. These measurements were not collected after 5 WAT because moving the vines for data collection after fruit set increased the risk of fruit detachment from vines.

Flower production. Flowers were counted weekly from 3 to 9 WAT between 0730 HR and 1200 HR on individual plants. Flowers that were open only on the day of counting were included in total weekly counts.

Fruit development. Cumulative fruit set was recorded during the same period as anthesis. Fruit set was determined and counted when the petals had dried and fallen off and the fruit had enlarged. Mature fruit were harvested, counted, and weighed. Rind thickness and soluble solids were evaluated to determine if pollenizer fruit could be marketed as a seeded watermelon. Rind thickness was measured on five cut fruit from each plot and measured from the outside of the fruit to where the interior of the fruit started to turn pink or cream in color. Rind thickness measurements were taken on both sides of the fruit at the equatorial position of the fruit. Soluble solids were measured with a handheld refractometer.

Data were analyzed using GLM and means were separated using Fisher's protected least significant difference ($P < 0.05$) (SAS Institute, 2002). Years were significantly different; thus, years are presented separately.

Table 1. Watermelon seed source and length of watermelon vine measured from the crown to the tip of the longest branch/plant/day for different pollenizer and triploid cultigens.

		Vine length (5 WAT)	
		2005	2006
Cultigen	Seed source[z]	(cm)	
Dwarf-length pollenizer cultigens			
Companion	SM	99.5 g[y]	58.0 gh
Sidekick	HM	96.5 g	77.0 fg
TP91	AC	104.0 g	50.5 gh
TPS92	AC	75.0 g	51.0 gh
WC5108-1216	SM	79.5 g	27.5 h
Standard-length pollenizer cultigens			
High Set 11	DN	173.0 f	133.5 de
Jenny	NU	244.0 de	104.5 ef
Mickylee	OP	293.0 abc	183.5 ab
Minipol	HZ	297.5 ab	194.0 a
Pinnacle	SW	237.0 e	171.0 abc
Summer Flavor 800	AC	277.0 bcd	165.0 abcd
SP1	SY	260.5 cde	159.5 abcd
WH6818	WH	312.0 a	137.0 cde
Triploid cultigens			
Petite Perfection	SY	271.0 bcd	137.5 cde
Tri-X-313	SY	287.0 abc	144.0 cd
Least significant difference		34.0	36.5

[z]Seed source: AC = Abbott & Cobb (Feasterville, PA); DN = Danson Seed (Los Angeles, CA); HM = Harris Moran, HZ = Hazera (Berurim M.P. Shikmim, Israel); NU = Nunhems (Acampo, CA); OP = open-pollinated, Willhite Seed (Poolville, TX); SM = Seminis (Oxnard, CA); SW = Southwestern (Casa Grande, AZ); SY = Syngenta (Boise, ID); WH = Willhite (Poolville, TX).

[y]Means within the column followed by the same letter are not significantly different at the 0.05 level using least significant difference.

WAT = weeks after transplant.

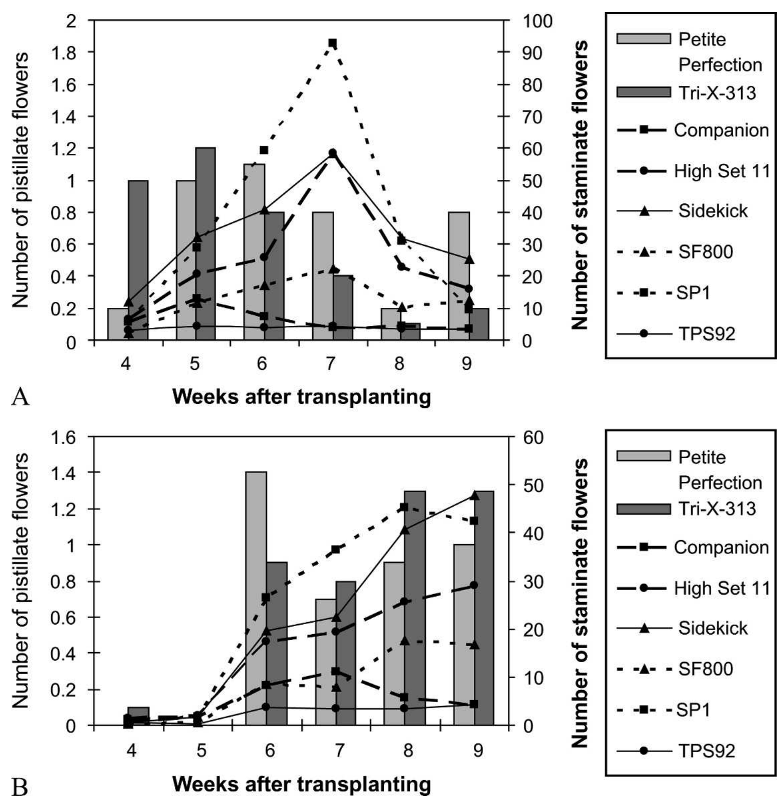

Fig. 1. Total number of watermelon pistillate flowers/plant/day (bars) on the triploid watermelon cultigens and total number of staminate flowers/plant/day (lines) on representative pollenizer watermelon cultigens in 2005 (**A**) and 2006 (**B**).

Results and Discussion

Vegetative development. Vine lengths over both years fit into two distinct vegetative categories (dwarf and standard) (Table 1). The difference between the two groups was noticeable at 4 WAT (data not shown); however, the differences became more distinct at 5 WAT. Dwarf cultigens included in these studies were 'Companion', 'Sidekick', 'TP91', 'TPS92', and 'WC5108-1216'. All other pollenizer cultigens had standard-length vines. The triploid watermelon cultigens had similar vine lengths to standard-length pollenizers. A dwarf cultivar of watermelon has shorter internodes caused by fewer cells in the internodes compared with a standard watermelon vine (Liu and Loy, 1972).

In both years, dwarf length cultigens had shorter internodes than cultigens we categorized as having a standard vine length (data not shown). Although not measured directly, the amount of branching varied between cultigens. 'High Set 11', 'Sidekick', and 'SP1' appeared to have substantial multibranching.

Vegetative development of the pollenizer may affect quantity and quality of triploid fruit. Dwarf types are theoretically less suited for the separate row planting method because staminate flowers produced by pollenizers may be a considerable distance from the triploid plants, which may hinder pollen transfer (Motsenbocker and Arancibia, 2002). Planting pollenizers in the same row as triploid plants minimize space between triploid and pollen source plants. Thus, the dwarf cultigens would likely be better suited for in-row planting to minimize the competition with triploid plants. In contrast, the use of standard-length cultigens may be better for the separate row planting method compared with the dwarf vine types. The separate row planting method maximizes the amount of space between the triploid and pollenizer plants. The larger space likely would result in less competition for nutrients, water, and light between the pollenizer and the triploid plants. Neppl et al. (2003) reported differences in vine vigor and growth among watermelon cultivars. The more vigorous growth of 'Mickylee' showed a trend to decrease fruit size and number compared with the smaller habit of 'SP1', a dedicated pollenizer (Freeman et al., 2007a). A vigorous vining pollenizer may act much like a weed and could reduce the yield and quality of the crop. Weed competition can reduce the yield and quality of many crops (Buker et al., 2003; Monks and Schultheis, 1998); however, a pollenizer is typically not given this consideration.

Triploid plants may cover the shorter internodes of the dwarf pollenizers minimizing visibility of flowers to bees. Standard-length cultigens with longer internodes may more effectively compete with the triploid plants.

Staminate flower production, 2005. Tables 2 through 4 were used to construct Figures 1A and 1B. The figure is included with the tables to illustrate different concepts. To minimize confusion and permit visual resolution in the figure, selected pollenizer cultigens were chosen to represent the different types of pollenizers. The earliest peak production of staminate flowers was at 5 and 6 WAT for 'Companion' (Table 2; Fig. 1A). Although this was the earliest peak time for staminate flowers relative to other cultigens, 'Companion' did not produce the most staminate flowers during those weeks. Compared with 'Companion', peak staminate flower production was later for a number of cultigens at 7 WAT. Two cultigens, which produced the most staminate flowers per plant per day at 6 and 7 WAT, were 'SP1' and 'Sidekick'. 'SP1' produced the most staminate flowers on a given day at 6 and 7 WAT. 'Sidekick' produced the highest number of staminate flowers at 4 and 9 WAT relative to the other cultigens. 'Sidekick' and 'SP1' produced a similar number of staminate flowers per day and were the leading producers of staminate flowers among other cultigens at 5 and 8 WAT. 'TP91' and 'TPS92', dwarf cultigens, produced the fewest staminate flowers during the entire experiment. The triploid cultigens produced a similar number of staminate flowers as the pollenizer cultigens with the lowest staminate flower production.

Staminate flower production, 2006. Staminate flower production peaked later in the 2006 experiment compared with 2005 (Tables 2–3; Fig. 1A–B). This delay was likely as a result of cooler temperatures at the time of transplanting. Daily peak production of staminate flowers for 'Companion' was 6 and 7 WAT (Table 3; Fig. 1B). Peak production of staminate flowers for the other cultivars was 8 and 9 WAT (Table 3).

Table 2. Total number of open staminate flowers/plant/day for different pollenizer and triploid watermelon cultigens in 2005.

	Weeks after transplant					
Cultigen	4	5	6	7	8	9
Dwarf-length cultigens						
Companion	5.5 bcde[z]	12.7 cde	7.3 fg	3.8 i	4.1 c	3.3 fgh
Sidekick	12.2 a	32.0 a	40.9 b	58.5 b	31.8 a	25.3 a
TP91	6.1 bcde	4.9 f	4.4 g	66.1 hi	3.0 c	2.1 h
TPS92	2.9 de	4.1 f	4.0 g	4.1 i	3.4 c	3.3 gh
WC5108-1216	5.2 cde	15.6 c	21.3 cd	16.2 fg	9.4 c	7.8 defg
Standard-length cultigens						
High Set 11	6.3 bcd	20.7 b	25.7 c	58.5 b	22.8 ab	16.0 b
Jenny	7.6 bc	13.8 cd	19.4 cde	27.0 d	23.1 ab	14.2 bc
Mickylee	7.9 bc	11.8 cde	15.9 def	25.4 de	13.2 bc	5.4 efgh
Minipol	5.1 cde	12.1 cde	11.2 efg	12.0 ghi	12.3 bc	8.7 def
Pinnacle	9.5 ab	13.3 cde	11.2 efg	14.1 fgh	7.5 c	5.1 efgh
Summer Flavor 800	2.2 e	11.8 cde	17.1 cde	22.5 def	10.2 c	12.5 bcd
SP1	5.5 bcde	28.8 a	59.3 a	92.6 a	30.9 a	9.5 cde
WH6818	9.0 a	15.4 c	20.9 cd	16.3 efg	14.0 bc	12.3 bcd
Triploid cultigens						
Petite Perfection	3.0 de	8.6 ef	12.7 defg	14.4 fgh	8.6 c	4.7 efgh
Tri-X-313	3.3 de	8.9 def	11.2 efg	14.4 fgh	4.0 c	3.3 fgh
Least significant difference	4.0	4.9	9.3	9.2	12.1	5.4

[z]Means within the column followed by the same letter are not significantly different at the 0.05 level using least significant difference.

Table 3. Total number of open staminate flowers/plant/day for different pollenizer and triploid watermelon cultigens in 2006.

	Weeks after transplant					
Cultigen	4	5	6	7	8	9
Dwarf-length pollenizer cultigens						
Companion	0.8 abcd[z]	1.7 ab	8.3 cdef	11.1 cd	5.6 fg	4.3 d
Sidekick	0.6 abcd	1.8 ab	19.5 b	22.6 b	40.8 a	47.9 a
TP91	1.0 abc	0.6 def	4.6 f	3.7 e	3.4 g	4.5 d
TPS92	0.6 abcd	0.2 f	3.8 f	3.3 e	3.6 g	4.4 d
WC5108-1216	0.5 bcd	1.3 bcd	7.8 cdef	12.1 c	18.5 bc	19.8 bc
Standard-length pollenizer cultigens						
High Set 11	1.3 ab	2.1 a	17.4 b	19.2 b	25.5 b	29.1 b
Jenny	0.3 cd	0.5 def	5.3 f	7.4 cde	13.2 cde	21.6 bc
Mickylee	1.1 abc	1.8 ab	10.3 cde	12.3 c	15.2 cde	18.6 bc
Minipol	1.3 ab	1.4 abc	8.3 cdef	11.3 cd	12.6 cdef	18.2 bc
Pinnacle	0.9 abcd	1.2 bcde	11.7 cd	11.3 cd	11.6 cdef	11.4 cd
Summer Flavor 800	0.3 cd	0.6 def	8.4 cdef	8.0 cde	17.5 cd	16.8 c
SP1	1.0 abc	1.8 ab	26.5 a	36.3 a	45.1 a	42.3 a
WH6818	0.8 abcd	1.1 bcde	7.1 def	6.0 de	10.6 defg	15.3 cd
Triploid cultigens						
Petite Perfection	0.1 d	0.4 ef	6.4 ef	7.3 cde	8.8 efg	10.2 cd
Tri-X-313	0.5 bcd	0.8 cdef	4.7 f	6.9 cde	11.6 cdef	12.2 cd
Least significant difference	0.8	4.8	4.8	5.7	7.2	11.9

[z]Means within the column followed by the same letter are not significantly different at the 0.05 level using least significant difference.

Staminate flower production after the peak production period was not examined because flower counts were stopped at 9 WAT because fruit set had occurred on the triploid plants and we used concurrent data acquisition times in the previous year's study. 'SP1' and 'Sidekick' produced the most staminate flowers per day 8 and 9 WAT. The third highest-producing cultigen of all the cultigens examined was 'High Set 11' and was comparable to 'SP1' or 'Sidekick' at 6 and 9 WAT. The dwarf vine cultigens, 'Companion', 'TP91', 'TPS92', and 'WC5108-1216', typically produced fewer staminate flowers per day than the standard vine types at 7, 8, and 9 WAT, whereas at 4, 5, and 6 WAT, these cultigens produced a similar number of staminate flowers compared with the standard vine types. 'TP91' and 'TPS92' produced very few staminate flowers per plant and never exceeded five per plant on a given day over the 6-week period that flowers were counted. The triploid cultigens produced the same number of staminate flowers per day as many standard-length pollenizers, which had an intermediate staminate flower response.

Pistillate flower production, 2005 and 2006. In 2005, the peak production of pistillate flowers for the triploid cultigens was at 6 WAT for 'Petite Perfection' and 5 WAT for 'Tri-X-313' (Fig. 1). In 2006, the peak production of pistillate flowers per day for the triploid cultivars, Petite Perfection and Tri-X-313, was 6 and 9 WAT, respectively.

Vine habit has an effect on the number of staminate and pistillate flowers that are produced. In cucumbers, little leaf types produce more branching than normal leaf and additional branching of the little leaf type cucumber results in higher flower and fruit production (Bowers et al., 1981; Goode et al., 1989; Schultheis et al., 1998). Watermelon flowers develop in the nodes (Rubatzky and Yamaguchi, 1997) and the obvious additional branching observed on 'Sidekick' and 'SP1' likely created more locations for flower development.

Staminate flower production on pollenizers should overlap with the production of pistillate flowers on triploid plants to maximize the pollination and set of triploid fruit. Maynard and Elmstrom (1992) discussed that earlier or later flowering pollenizers affected the timing of triploid fruit harvest. Several cultigens had consistent, prolific staminate flower production through the season (i.e., 'SP-1', 'Sidekick', and 'High Set 11') (Fig. 1). This continuous production might extend triploid fruit production and expand the length of harvest time. 'Companion' produced staminate flowers earlier in the season, which may lead to earlier triploid fruit set and harvest. In 2005, pistillate flower production of the triploids overlapped best with 'Companion' staminate flower production. 'Petite Perfection' had peak production of pistillate flowers at the same time as the peak production of staminate flowers on 'WC5108-1216'. In 2006, peak pistillate flower production per day of the triploid fruit overlapped with the peak production of staminate flowers on all pollenizer cultigens, except 'Companion'. Staminate flower production does not necessarily need to overlap with triploid pistillate flower production, because there likely is an adequate amount of viable pollen being produced by pollenizers during some of its off-peak times. However, for the best chance of triploid fruit set and quality, peak pollenizer staminate flower production should coincide with triploid pistillate flower production.

Fruit development, 2005. Most cultigens had set one fruit per plant 5 WAT (data not shown). Beginning 5 WAT, 'Sidekick' and 'SP1' continued to set one or more fruit throughout the 5-week period (Table 4). 'High Set 11' averaged 0.5 or more fruit per week between 6 and 9 WAT. 'Companion' fruit set was complete 6 WAT with approximately two fruits per plant. By 9 WAT, a total of eight fruit and 13 fruit were set per 'SP1' and 'Sidekick' plants, respectively. Other cultigens set between two and five fruits per plant between 5 and 9 WAT. Most cultigens set two or three fruit per plant by 6 WAT and one to two additional fruits were set in the subsequent 3 weeks. 'Petite Perfection' set most of its fruit 6 and 9 WAT and 'Tri-X-313' set most of its fruit 6 and 8 WAT.

Fruit development, 2006. Delay in staminate flowers caused a corresponding delay in fruit set compared with 2005 with most cultigens not beginning to set fruit until 6 WAT (Table 4). 'Jenny', 'SF800', and 'WC5108-1216' set less than one fruit per plant until 9 WAT. 'SP1' and 'Sidekick' set the most fruit by 9 WAT. 'Companion', 'TP91', and 'TPS92' initially set one fruit per plant 6 WAT with limited fruit set thereafter. The other cultigens had their first fruit set by 6 or 7 WAT and then a second by 8 to 9 WAT. Concentrated fruit set for the triploid cultigens occurred by 9 WAT.

Fruit quality, 2005 and 2006. Fruit interior was examined to determine the acceptability of pollenizer cultigens for potential sales of seeded watermelon. In 2005 and 2006, the pollenizer cultigens with a rind thickness greater than 10 mm were 'Companion', 'Mickylee', 'SF800', 'TP91', 'TPS92', and 'WC5108-1216' (Table 5). Furthermore, all the cultigens except 'Companion', 'TP91', 'TPS92', and 'WC5108-1216' had the same rind width as 'Petite Perfection'. In 2006, 'High Set 11', 'Jenny', 'Pinnacle', and 'WH6818' had the same rind thickness as 'Petite Perfection'. The cultigens with the thinnest rinds were 'High Set 11', 'SP1', and 'Sidekick'.

'SF800' and 'Tri-X-313' have a thick rind and are shipped and marketed in bins. Based on rind thickness alone, 'Companion', 'Mickylee', 'TP91', 'TPS92', and 'WC5108-1216' all meet the criteria for shipment and marketing in bins. 'Petite Perfection' is a mini watermelon cultivar that has a thinner rind than the standard-sized triploid fruit such as 'Tri-X-313', 'High Set 11', 'SP1', and 'Sidekick' are cultigens with a thinner rind that easily collapses if stepped on in the field and are less likely to result in injury to workers.

Table 4. Cumulative number of set watermelon fruit/plant/day for different pollenizer and triploid watermelon cultigens.

	2005		2006	
	Weeks after transplant			
Cultigen	6	9	6	9
Dwarf-length pollenizer cultigens				
Companion	2.1 efgh[z]	2.0 e	1.2 cde	1.6 g
Sidekick	6.3 a	13.6 a	4.2 a	10.9 a
TP91	1.3 gh	2.1 e	1.2 cde	1.6 g
TPS92	1.1 h	2.2 e	1.1 cde	1.9 fg
WC5108-1216	2.6 cdef	4.3 cde	0.1 e	2.9 efg
Standard-length pollenizer cultigens				
High Set 11	3.5 bc	5.6 cd	0.9 de	5.4 bcd
Jenny	3.3 bcd	5.3 bc	0.6 de	4.9 bcde
Mickylee	2.1 efgh	3.8 cde	1.4 bcd	3.3 defg
Minipol	2.3 defg	4.1 cde	1.5 bcd	3.5 defg
Pinnacle	2.8 bcdef	3.9 cde	2.1 bc	4.8 cde
Summer Flavor 800	1.6 fgh	2.4 e	0.4 de	3.3 defg
SP1	3.5 bc	8.3 b	1.0 cde	7.1 b
WH6818	3.0 bcde	5.2 cd	1.1 cde	3.9 cdef
Triploid cultigens				
Petite Perfection	3.9 b	5.8 bc	0.5 de	4.8 cde
Tri-X-313	2.2 efgh	3.1 de	0.5 de	4.3 cde
Least significant difference	1.1	2.5	1.1	2.3

[z]Means within the column followed by the same letter are not significantly different at the 0.05 level using least significant difference.

Table 5. Average mass, rind thickness, and soluble solids of different pollenizer and triploid watermelon cultigen fruit in 2005 and 2006.

	Fruit mass		Rind thickness		Soluble solids	
	2005	2006	2005	2006	2005	2006
Treatment	(kg)		(mm)		(°Brix)	
Dwarf-length pollenizer cultigens						
Companion	3.9 def[z]	3.8 de	11.5 bcde[z]	10.6 c	11.7 a	10.4 abcde
Sidekick	0.9 i	1.0 i	5.6 ef	4.9 ef	9.5 abc	9.0 ef
TP91	4.8 cd	4.2 cd	0.2 a	13.0 b	6.9 cde	9.4 def
TPS92	4.7 cde	4.2 cd	16.0 abc	12.4 bc	6.0 de	11.0 abcd
WC5108-1216	3.4 defg	3.3 def	17.2 ab	12.9 b	10.1 ab	9.9 abcdef
Standard-length pollenizer cultigens						
High Set 11	2.0 ghi	2.5 fgh	8.3 def	8.6 d	7.5 bcde	8.3 f
Jenny	2.6 fgh	3.3 fgh	8.0 ef	7.4 d	9.4 abc	10.1 abcde
Mickylee	5.5 bc	5.1 c	15.2 abcd	12.8 b	8.2 abc	10.8 abcd
Minipol	3.3 efg	3.9 de	8.3 edf	12.3 bc	9.2 abc	11.1 abc
Pinnacle	3.1 fg	2.9 efg	9.3 cdef	8.4 d	10.3 ab	11.3 ab
Summer Flavor 800	7.8 a	10.7 a	17.4 ab	16.0 a	9.2 abc	11.6 a
SP1	1.4 hi	2.0 ghi	3.4 f	6.7 de	4.7 e	4.5 g
WH6818	3.0 fg	2.9 efg	8.7 def	8.5 d	8.2 abc	9.5 cdef
Triploid cultigens						
Petite Perfection	2.4 fgh	3.1 efg	8.4 def	7.9 d	10.5 ab	11.1 abc
Tri-X-313	6.6 ab	8.3 b	17.0 ab	16.5 a	8.5 abcd	11.9 abcd
Least significant difference	0.8	0.6	7.1	1.9	3.0	1.6

[z]Means within the column followed by the same letter are not significantly different at the 0.05 level using least significant difference.

For watermelon fruit to be marketable, watermelon should have a minimum °Brix (soluble solids) of 10.0 (USDA, Agricultural Marketing Service, 2006). The only cultigens to have soluble solids at this level in 2005 were 'Companion', 'Pinnnacle', 'SF800', and 'WC5108-1216' (Table 5). In 2006, additional cultivars included Jenny, Mickylee, Minipol, and TPS92. Cultigens with the lightest red flesh color were 'Mickylee', 'Sidekick', 'TP91', and 'TPS92'. 'SP1' has a white flesh color that turns cream as it ages. 'High Set 11' segregated red, pink, white, and orange-colored flesh. 'TP91', 'TPS92', and 'WC5108-1216' had thick rinds characteristic of marketable fruits. However, they had a °Brix, which was generally less than 10.0 and therefore would not be suited for market.

This research was not focused on pollenizer cultigens that were suitable for market. However, we would be remiss if we did not at least consider their potential because they are an economic consideration should the producer want to consider their suitability for market. There is still demand in many markets for seeded watermelon. Some of the new dedicated pollenizer cultivars that meet the fruit quality criteria for market are 'Pinnacle' and 'Minipol'. 'Jenny' has good fruit quality and is currently sold in Europe but not in the United States. Our conclusions are based on fruit with acceptable red flesh color and sugars. 'Pinnacle' and 'Jenny', however, have thinner rinds and may require special packaging. 'Mickylee' and 'SF800' are commonly grown for commercial sale but also used as pollenizers in North and South America.

When selecting a pollenizer, vegetative, floral, and fruit characteristics should be considered. Factors that could have the most impact on the yield of triploid watermelon production are the quantity and timing of peak production of staminate flowers and vine growth of the pollenizer. Although a cultigen may have higher quantities of staminate flowers per plant compared with other cultigens, the higher number of staminate flowers may not coincide with a high quantity of pollen (Stanghellini and Schultheis, 2005). Freeman et al. (2008) found no variability in pollen viability of diploid watermelon pollenizers. Thus, pollen production and not viability most likely has greater influence on triploid fruit set. In subsequent studies, pollen production of these cultigens should be quantified.

Motsenbocker and Arancibia (2002) and Sanders et al. (1999) showed reducing in-row spacing between watermelon plants cause fruit size and number of fruit per vine to decline. However, these two research studies did not examine dedicated pollenizer cultigens. When spacing cucumber plants, reducing the in-row spacing had the same effect on little leaf cucumber with a multibranching and regular leaf cucumber (Bowers et al., 1981). Thus, the multibranching habit of 'SP1' and 'Sidekick' with more side branching may have limited effect on the production of triploid fruit when pollenizers are interplanted in the same row as transplants. Dwarf plant structure has been used in other crops such as apple, peach, and nectarine to maximize planting density (Vizzoto and Costa, 1997; Weber, 2001). The cultigens used in this study with a dwarf vine structure could be planted at higher quantities or interplanted with triploid watermelons to maximize the number of staminate flowers in the field with potentially little effect on the yield of the triploid fruit.

Conclusions

Overall, growers have several options when selecting pollenizer cultigens. These options vary in vegetative, floral, and fruit production, which agrees with conclusions by Freeman and Olson (2007c). We recognize that vegetative, floral, and fruit growth we measured in these studies may be altered when interplanted with a commercial triploid planting. However, many of the general differences described in this study will likely be consistent in commercial watermelon plantings. These cultigens need to be tested under growers' conditions. Freeman et al. (2007b) examined selected dedicated pollenizers in triploid production, but additional work needs to be conducted on different dedicated pollenizers and consideration given to planting arrangement and densities.

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