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Staminate and Pistillate Flower Production of Summer Squash in Response to Planting Date

D.S. NeSmith[1] and G. Hoogenboom[2]
The University of Georgia, Georgia Station, Griffin, GA 30223-1797

D.W. Groff
Asgrow Seed Company, Route 1 Box 1907, Tifton, GA 31794

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Abstract. **Staminate and pistillate flower production in summer squash *(Cucurbita pepo* L.) fluctuates readily in response to the various crop production environments throughout the southeastern United States. 'Dixie', 'Senator', 'Lemondrop', 'Meigs', and 'Elite' squash were planted at various times over 2 years in Griffin, Ga., to determine the effect of planting date on staminate and pistillate flower counts for the first 2 weeks of flowering. Staminate and pistillate flower counts varied considerably depending on cultivar and time of planting, but no consistent pattern emerged. The production of staminate flowers was generally more variable than that of pistillate flowers. The distillate : staminate flower ratio was generally stable for 'Senator' and 'Elite', but not for the other cultivars, particularly 'Dixie'. 'Dixie' produced more distillate than staminate flowers 50% of the time, whereas 'Senator' always produced more staminate flowers. Pistillate flower production for 'Senator' and 'Elite' was restricted during hot weather. These data indicate that staminate and pistillate flower counts of squash fluctuate under varying environmental conditions and that maintaining production over a range of planting dates will depend on careful cultivar selection.**

Summer squash are produced extensively throughout the southeastern United States at various times of the year. About 11,000 ha of this crop is grown annually in Georgia alone (Mizelle, 1993). In some areas of Georgia, growers have attempted to produce a continuous supply of squash from spring through fall, but there have been problems with maintaining productivity, especially during hot summer months. One cause of low productivity during midsummer has been related to an apparent decline in distillate flower production under conditions of long, hot days. Also, growers sometimes report an excess of staminate or pistillate flowers which maybe related to growing conditions. Research is needed to better quantify the flowering response of contemporary summer squash cultivars grown under differing environments.

Environmental influence on flower sex and sex ratio in cucurbits has been studied to an extent, but much of the work is several decades old and involves outdated cultivars. Tiedjens (1928) reported that long days favor staminate flower production and short days favor pistillate flower production in cucumber *(Cucumis sativus* L.); however, temperature was not controlled or reported. Whitaker (1931) suggested that a majority of staminate flowers are produced in cucurbits under most conditions and that environment can influence the sex ratio. He further postulated that quantitative differences in sex expression likely exist among cultivars. Nitsch et al. (1952) indicated that daylength apparently influences flower sex in squash, but that temperature has a more pronounced effect. Generally, they found that temperatures up to 30C promoted staminate flower production and that more staminate flowers are produced than pistillate flowers most of the time. Sutherland (1986) found that of 265 plant species studied, only 7% had female: male ratios greater than unity. Sedgley and Buttrose (1978) reported that the proportion of staminate flowers in watermelon *[Citrullus lanatus* (Thunb.) Matsum. & Nakai] increased with temperature and that light did not greatly influence floral sex expression. In a recent study involving constant-temperature environments, Woodson and Fargo (1991) showed that the number of squash staminate flowers increased with temperature from 20C up to 27.5C, and then began to decline. The number of pistillate flowers remained constant over this same temperature range; thus, the sex ratio change was due to the fluctuating number of staminate flowers.

These results indicate that the number of staminate and pistillate flowers in cucurbits, including summer squash, is highly variable, depending on both environment, especially temperature, and cultivar. Flower sex is determined for cucurbit crops as early as the two-true-leaf growth stage (Hume and Lovell, 1983; van der Vlugt, 1983); thus, the temperature the first 2 weeks after seeding likely will influence early flower sex ratio. The objective of our research was to assess the influence of planting date on staminate and pistillate flower production for five squash cultivars grown under field conditions during 2 years.

Materials and Methods

'Dixie', 'Senator', 'Lemondrop', 'Meigs' (Asgrow Seed Co., Kalamazoo, Mich.), and 'Elite' (Harris Seeds, Rochester, N.Y.) summer squash were grown in eight separate experiments in Griffin, Ga., over 2 years to collect data concerning staminate and pistillate flower production. 'Dixie' and 'Meigs' are yellow crookneck squash, 'Lemondrop' is a yellow straightneck cultivar, and 'Senator' and 'Elite' are zucchini cultivars. The sowing dates, types of cultivars grown, and mean temperature the first 2 weeks after sowing for each experiment are listed in Table 1. Similar cultural practices were used in all experiments. Row width was 0.9 m, and in-row plant spacing was 0.6 m. Squash plants were grown in three-row plots (9-m-long rows) in a completely randomized block design with three replications. Seeds were planted by hand with four seeds per hill and were thinned to one plant per hill after emergence. Fertilizer applications consisted of 230 $kg\cdot ha^{-1}$ of 10N–4.4P–8.3K incorporated before planting, and 165 $kg\cdot ha^{-1}$ of 34N–0P–0K sidedressed 3 weeks after emergence. Irrigation was used in all experiments to supplement rainfall. Recommended pesticides were used to control weeds and insects as needed.

Sample plants on which flower counts were made for 2 weeks after flowering began were marked in each plot. For each experiment, nine to 15 plants per cultivar (three to five plants per replication) were assessed every 2 to 3 days to determine the number of distillate and staminate flowers present. Only flowers that were open or that had opened since the last sample day were counted. Flower petals were removed during each sample interval to facilitate future enumeration. Plants with virus symptoms or other abnormalities were eliminated from data analysis. Statistical analyses consisted of testing for cultivar and planting date main effects and interaction, and calculating least significant differences at $P < 0.05$.

Table 1. Sowing dates, types of cultivars, and mean temperature the first 2 weeks after sowing summer squash in Griffin, Ga., in 1991 and 1992.

Planting identification			Mean temp (°C)
No.	Sowing date	Cultivars grown[z]	first 2 weeks after sowing
1991			
1	3 Apr.	D, S, E, L	18.5
2	4 June	D, S, E, L, M	23.4
3	12 July	D, S, E, L, M	26.2
4	28 Aug.	D, S, E, L, M	24.1
5	12 Sept.	D, S, E, L, M	23.2
1992			
6	6 Apr.	D, S, E, L, M	18.3
7	2 June	D, S, E, L	22.4
8	1 Sept.	D, S, E, L, M	23.4

[z]D = 'Dixie', S = 'Senator', E = 'Elite', L = 'Lemondrop', and M = 'Meigs'.

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[1]Dept. of Horticulture.
[2]Dept. of Biological and Agricultural Engineering,

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Results and Discussion

There was a significant cultivar × experiment interaction for staminate and pistillate flower counts (Table 2). There was variability in the number of flowers of each sex produced within cultivars and planting dates. Planting date influenced staminate flower count more than pistillate flower count for all cultivars. This response was similar to that observed by Woodson and Fargo (1991). The lowest staminate flower counts occurred following planting date 3 (12 July 1991) for 'Senator' and 'Elite'.

Pistillate flower counts were more stable than staminate flower counts over a wide range of planting dates for the cultivars. Again, 'Senator' and 'Elite' had the fewest pistillate flowers for planting date 3. These cultivars are apparently sensitive to the high temperatures that occurred during this growth interval. 'Senator' has a lower optimum temperature for germination than 'Dixie' and 'Lemondrop', and 'Senator' germinated better at low temperatures than did the other two cultivars (NeSmith and Bridges, 1992), Thus, 'Senator' and 'Elite' (or cultivars that respond similarly) may be the better choice for production during cooler portions of the season. However, when production is planned during warmer months, other cultivars would be better selections.

The pistillate : staminate flower ratio was more stable for 'Senator' and 'Elite' than for the other cultivars, and was generally less than unity (Table 3). An exception was the value for 'Elite' in response to planting date 3. This result is likely an anomaly since the flower count for both sexes was extremely low for this cultivar planted on this date. The ratio fluctuated from far below to far above unity for the other cultivars, especially 'Dixie'. 'Dixie' had a pistillate : staminate ratio ≥1 half of the time. This ratio is surprising, especially in view of Sutherland's (1986) observations of the sex ratio of 265 species. He reported that number of pistillate flowers exceeded staminate flowers in only 7% of the instances, indicating that a pistillate : staminate ratio <1 was the norm. Apparently, 'Dixie' is an exception to this generality and may explain why it has continued to perform well under a wide range of environments for many years.

The instability of the sex ratio for some of the cultivars indicates that this is not a suitable trait for evaluating potential cultivar performance. Pistillate flower count may be more useful, assuming enough staminate flowers are present. Growers in Georgia have indicated that, under some growing conditions, only male or female flowers occur. Instances of "all males" or "all females" were absent in our experiments; 'Senator' and 'Elite' at planting date 3 (July 1991) were the closest exceptions. However, the number of both sexes of flowers was low during this growth interval.

We have shown that squash staminate and pistillate flower counts fluctuate readily under various field environments. However, we were unable to identify a distinct pattern of flower sex production for each cultivar. There was no strong, consistent correlation of total flower count or sex ratio with temperature soon after seedling emergence. These squash cultivars apparently will produce both flower sexes when grown over a range of environments. High temperature might influence successful pollination, but this was not assessed in these experiments. If growers intend to produce squash from early spring through the fall, careful consideration needs to be given to cultivar selection. It is likely that cultivars similar to 'Senator' and 'Elite' will not maintain production during extremely high temperatures.

Table 2. Total number of staminate and pistillate flowers the first 2 weeks of flowering for summer squash started at eight planting dates (see Table 1) in Griffin, Ga., during 1991 and 1992.

Planting no.	Cultivar (flowers/m^2)					
	Dixie	Senator	Elite	Lemondrop	Meigs	$LSD_{0.05}$
	Staminate flowers					
1991						
1	5.0	12.2	14.2	7.0	---	5.7
2	19.8	6.1	8.2	10.6	15.3	3.5
3	8.5	2.4	0.5	5.9	6.7	3.5
4	12.4	10.5	9.1	10.4	11.6	2.3
5	6.7	7.4	6.3	6.1	7.6	1.9
1992						
6	11.3	14.8	14.1	10.9	11.8	2.2
7	24.8	20.0	18.1	20.2	---	4.4
8	16.2	10.2	11.8	13.7	12.7	2.3
$LSD_{0.05}$	3.9	2.4	3.0	2.8	4.1	
Cultivar (C)	**					
Experiment (E)	**					
C × E	**					
	Pistillate flowers					
1991						
1	9.2	6.1	6.8	8.9	---	4.1
2	8.5	2.3	4.6	5.0	8.7	2.3
3	7.0	0.2	0.8	5.9	8.1	2.2
4	8.3	3.3	4.4	5.3	8.7	1.6
5	8.0	2.2	2.8	4.9	6.3	1.9
1992						
6	15.1	7.3	6.9	7.5	9.6	2.3
7	8.2	6.4	8.9	8.6	---	2.5
8	15.6	5.0	7.0	7.7	10.9	2.1
$LSD_{0.05}$	2.5	2.0	2.4	2.1	3.0	
Cultivar (C)	**					
Experiment (E)	**					
C × E	**					

**Significant at $P \leq 0.01$.

Table 3. Pistillate : staminate flower ratio the first 2 weeks of flowering for summer squash started at eight planting dates (see Table 1) in Griffin, Ga., during 1991 and 1992.

Planting no.	Cultivar				
	Dixie	Senator	Elite	Lemondrop	Meigs
1991					
1	1.8	0.5	0.5	1.3	---
2	0.4	0.4	0.6	0.5	0.6
3	0.8	0.1	1.6	1.0	1.2
4	0.7	0.3	0.5	0.5	0.8
5	1.2	0.3	0.4	0.8	0.8
1992					
6	1.3	0.5	0.5	0.7	0.8
7	0.3	0.3	0.5	0.4	---
8	1.0	0.5	0.6	0.6	0.9

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