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Variability in Watermelon Flower Attractiveness to Insect Pollinators

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In the Spring and Fall of 2006, pollinator preference of diploid watermelon [*Citrullus lanatus* (Thunb.) Matsum. & nakai.] pollenizers was recorded at Quincy, FL. Triploid watermelon plants do not produce sufficient viable pollen to pollenize themselves and a diploid cultivar must be planted in the field as a pollen source. Recent studies have illustrated differences in triploid watermelon yields as a result of the pollenizer cultivar selection. Pollinator preference of watermelon pollenizers may greatly affect the amount of viable pollen that is being moved throughout a field and thus the amount of triploid fruit that will be set. Pollinator visitations were recorded for the pollenizer cultivars Companion, Mickylee, and SP-1, and the triploid cultivar Intruder. Visitation to 'Mickylee' and 'SP-1' was greater than that of 'Companion'. Visitation of the diploid cultivars was also greater than that of the triploid cultivar. 'Companion' has recently been shown to be a less effective pollenizer than 'Mickylee' or 'SP-1' and lower visitation by pollinators may be a contributing factor. 'Companion' has a nearly entire leaf and staminate flowers that are produced on short peduncles. In many cases this may obstruct the view of the staminate flowers, which may reduce the pollinator visitation as visual cues are used in long-range foraging decisions. It is important that a pollenizer cultivar be more attractive to pollinators than the triploid because foraging of triploid staminate flowers can reduce the percentage of viable pollen being moved throughout a field. This study suggests that pollenizer attractiveness to pollinators may be an important factor that determines a pollenizer's performance.

In a field that is producing triploid seedless watermelons, there must be both diploid and triploid plants (Kihara, 1951; Maynard and Elmstrom, 1992). For fruit set to occur in triploid plants, pollen must be moved from a staminate diploid flower (pollenizer) to a pistillate triploid flower. Recent studies have illustrated differences in performance between in-row pollenizer cultivars. Freeman et al. (2007) reported that triploid plants pollenized by 'Companion' yielded significantly less than plants pollenized by 'Mickylee' and 'SP-1', as well as others.

In cultivated watermelon crops, domesticated honeybees (*Apis mellifera* L.) are the most important pollinator (Free, 1993). Walters (2005) illustrated that increased honeybee visitation to pistillate triploid flowers is required for fruit set due to the dilution of viable diploid pollen with non-viable triploid pollen. Both triploid and diploid watermelon plants produce visually similar staminate flowers, and triploid flowers produce pollen although it is not viable.

Honeybee foraging habits are controlled by both visual and olfactory cues (Butler, 1951; von Frishch 1967). These cues are processed during pre-alighting inspection and determine whether the flower will be foraged. It has been shown that floral structures such as petals, sepals, gynoecium, and pollen have distinct volatile emissions that are species and genotype specific (Dobson, 1991; Dobson et al., 1996, 1987). The volatiles from pollen (which are derived from pollenkitt) are the most important factors when honeybees decide to forage a flower or not (Pernal and Currie, 2002). The olfactory cues from pollen also appear to be quantitative, and decreasing emissions throughout the day indicate less reward to foragers (Dobson et al., 1996).

It has been suggested that pollen odor may be distinct between male-fertile and male-sterile flowers of the same species (Dobson et al., 1996). Preference for male-fertile over male-sterile potato flowers has been shown in bumblebee (*Bombus* spp. Cresson) (Arndt et al., 1990; Batra, 1993). The preference reported may have been due to pollen odor. Wolf et al. (1999) conducted pollinator preference experiments in which honeybees were placed in a field with two watermelon cultivars, one wild-type watermelon [*Citrullus colocynthis* (L.) Schrad.] accession and one *C. colocynthis* x *C. lanatus* hybrid 'BAG', with the number of visitations being recorded. Significantly greater bee visitation was seen in the watermelon cultivar BAG and the *C. colocynthis* accession, neither of which had nectar volume, pollen quantity, or flower size that was different from the other genotypes tested. Wolf et al. (1999) found a positive correlation between honeybee visitation and sugar concentration of nectar, which is what greater visitation was attributed to. This conclusion is in contrast to that of Pernal and Currie (2002), who illustrated that pollen odor was more important than forage quality for honeybees.

If staminate flowers produced by the diploid pollenizer are more attractive than triploid staminate flowers, a greater proportion of viable pollen could be moved by pollinators, which may lead to greater triploid fruit set. It may be possible that floral attractiveness of a pollenizer could impact its performance. The objective of this study was to determine the floral attractiveness of staminate flowers of three pollenizer cultivars and one triploid cultivar.

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Materials and Methods

Field experiments were conducted at the North Florida Research and Education Center (NFREC) in Quincy, FL, during the Spring and Fall of 2006. Soil type at NFREC was Norfolk loamy sand (fine-loamy, kaolinitic, thermic, Typic Kandiudults). The experimental design was a randomized complete block with eight replications. The attractiveness of four watermelon cultivars to insect pollinators was determined. Diploid pollenizer cultivars Companion, Mickylee, and SP-1 were used along with the triploid cultivar Intruder. On 3 Apr. and 1 Aug. 2006, 4-week-old watermelon seedlings were transplanted into raised beds covered with black polyethylene mulch in the spring and white on black polyethylene mulch in the fall. Plots consisted of three watermelon plants spaced 0.46 m in-row and 4.9 m between row. There was a buffer of 3.19 m between each plot to maintain separation between cultivars. Fertilization, irrigation, and pesticide application practices recommended by the University of Florida Institute of Food and Agricultural Sciences were followed (Olson et al., 2006). A grouping of two honeybee hives was placed near the center of the experiment.

Sampling was performed on five occasions in the spring and three in the fall. Sampling started when plants began to produce staminate and pistillate flowers. On sampling dates, sampling was initiated at anthesis. Five staminate flowers were chosen in each plot and visitations from honeybees and bumblebees were counted for 2 min. Three to four sampling repetitions were performed on each sampling date and are referred to as sampling time. Previous research has illustrated an interaction between cultivar attractiveness and sampling time; for this reason, sampling times were kept succinct and sampling time was considered a main effect. Two individuals recorded visitations to keep individual sampling repetition time under 45 min. Analysis of variance was performed using the GLM procedures of SAS (SAS Institute, Inc., Cary, NC) to determine significance of main and interaction effects, and Duncan's multiple range test was used for means separation.

Results

Watermelon cultivar and sampling time had a significant effect ($P \leq 0.05$) on floral visitation by insect pollinators on six of eight sampling dates. Cultivar or sampling time did not influence pollinator visitation on 11 May or 29 Sept. Significant interactions ($P \leq 0.05$) between time and cultivar were detected on 23 May and 22 Sept. Visitation of a diploid cultivar was significantly greater than the triploid cultivar on six of eight sampling dates.

On 16 May, 'SP-1' had 2.4 visits per plot, which was significantly greater than 'Mickylee', 'Companion', or 'Intruder', which had 1.1, 1.0, and 0.8 visits per plot, respectively (Fig. 1). Pollinator visitation of 'Mickylee', 'Companion', or 'Intruder' was not significantly different. Pollinator visitations to 'Mickylee' and 'SP-1' were 2.9 visits per plot, which was significantly greater than 'Companion' or 'Intruder', which had 1.5 and 1.0 visits per plot, respectively, on 19 May. An interaction between sampling time and cultivar occurred on 23 May. During the first sampling time, 'SP-1' had 4.2 visits per plot, which was not significantly greater than 'Companion' or 'Mickylee', which had 3.0 and 2.75 visits per plot, respectively (Fig. 2). However, all three cultivars had significantly greater visitation than 'Intruder' at 0.3 visits per plot. During the second sampling time, 'Mickylee' had 5.5 visits per plot, which was not significantly different than 'SP-1' at 2.8 visits per plot but was significantly greater than 'Intruder' and 'Companion' at 1.5 and 1.3 visits per plot, respectively. Visitation of 'SP-1', 'Intruder', and 'Companion' were not significantly different. There were no significant differences between cultivars during the third and fourth sampling times. On 25 May, 'Mickylee' had 2.8 visits per plot, which was

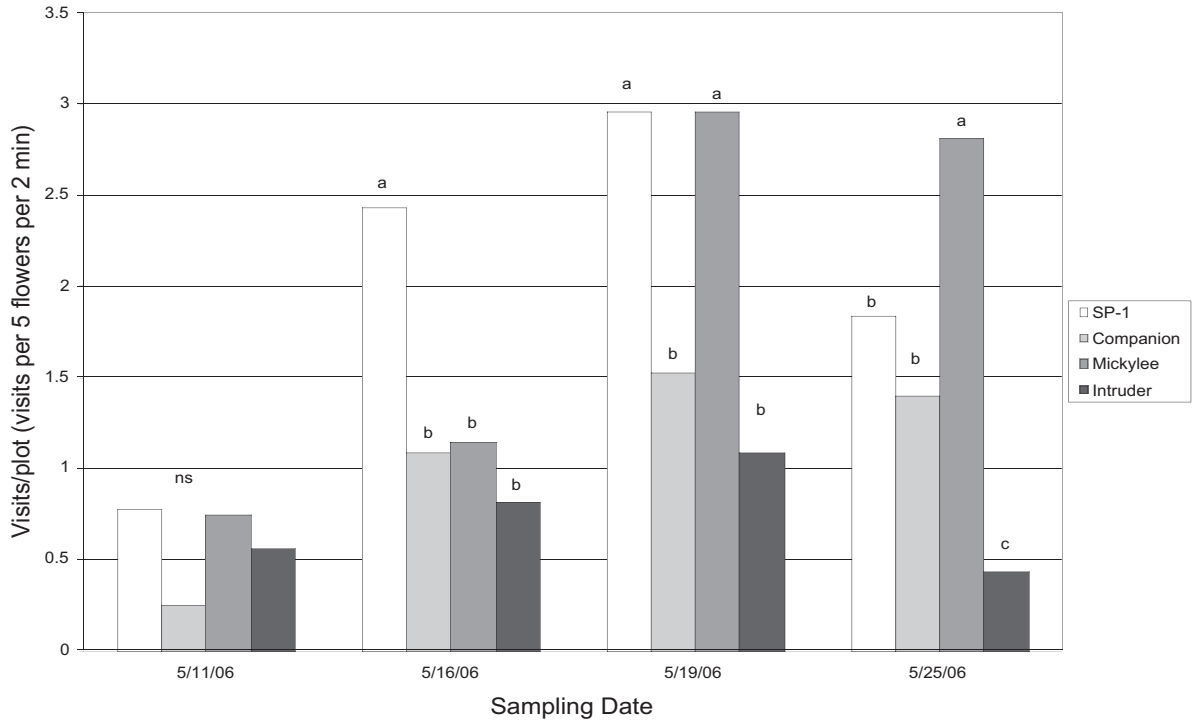

Fig. 1. Influence of cultivar on pollinator visitation to staminate watermelon flowers at Quincy, FL, Spring 2006. Visitation means are to be compared within sample date. Means not followed by the same letter are significantly different at $P \leq 0.05$.

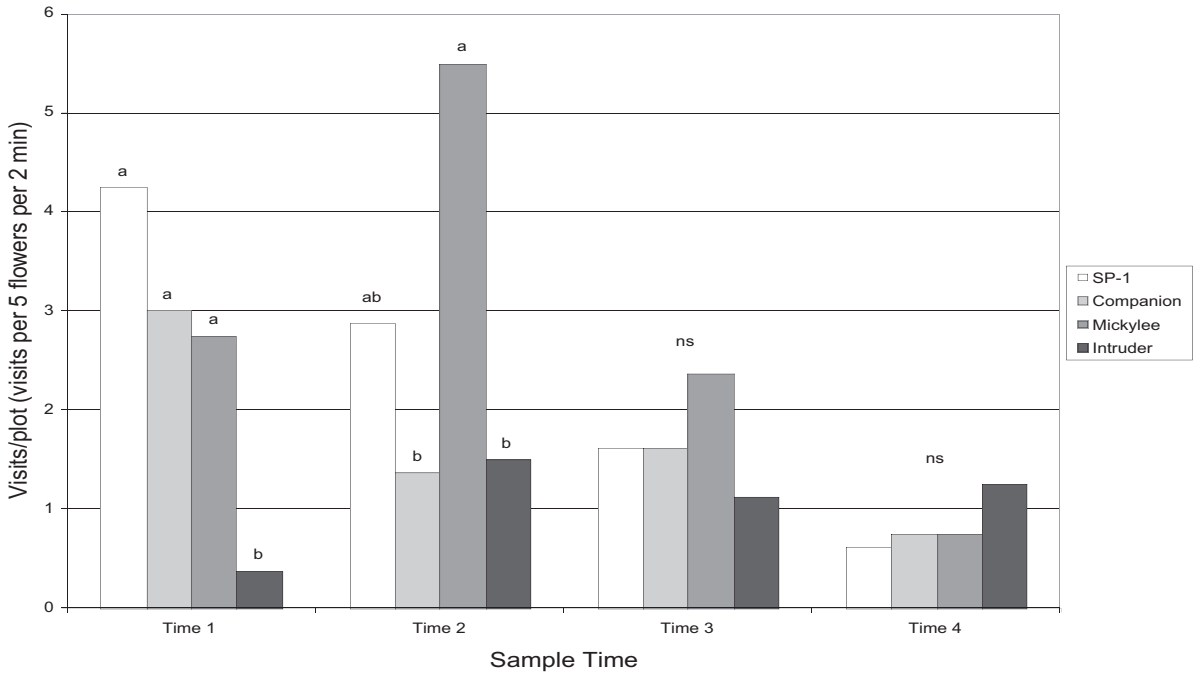

Fig. 2. Interaction effect of cultivar and time on pollinator visitation to staminate watermelon flowers at Quincy, FL, on 23 May 2006. Visitation means are to be compared within sample time. Means not followed by the same letter are significantly different at $P \leq 0.05$.

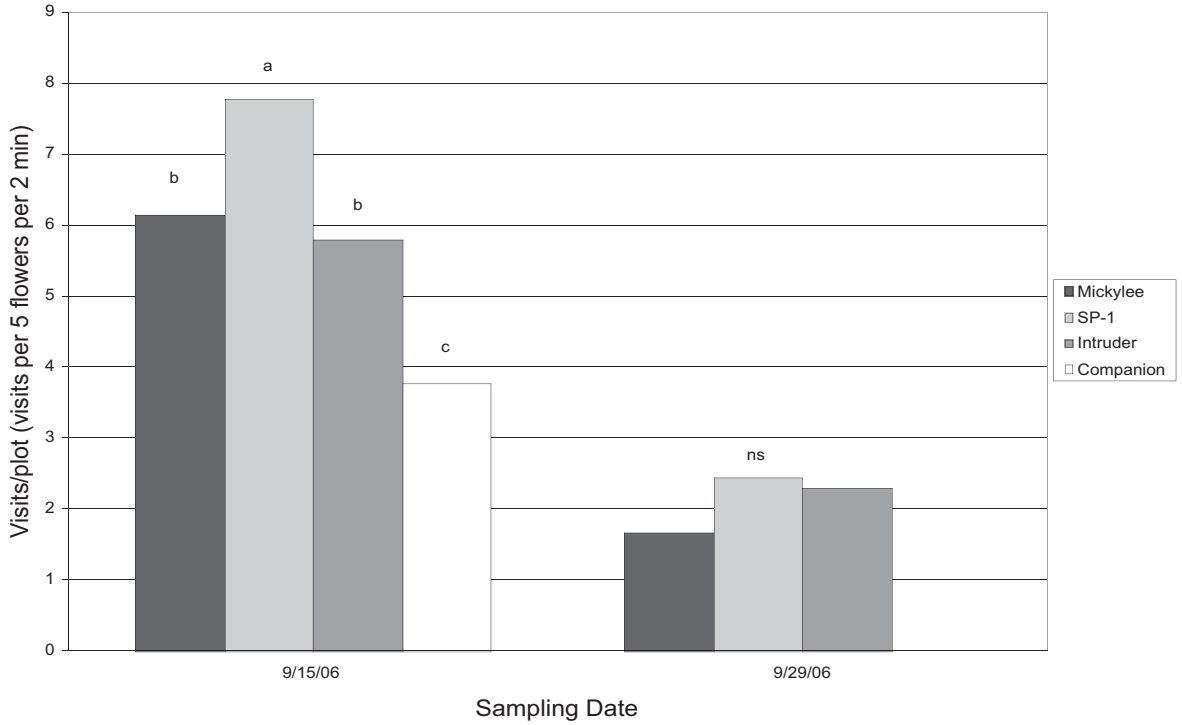

Fig. 3. Influence of cultivar on pollinator visitation to staminate watermelon flowers at Quincy, FL, Fall 2006. Visitation means are to be compared within sample date. Means not followed by the same letter are significantly different at $P \leq 0.05$.

significantly greater than 'SP-1', 'Companion', or 'Intruder' at 1.8, 1.4, and 0.4 visits per plot, respectively (Fig. 1). 'SP-1' and 'Companion' were not significantly different but both had greater visitation than 'Intruder'.

On 15 Sept, 'SP-1' had 7.7 visits per plot, which was greater than 'Mickylee', 'Intruder', or 'Companion' at 6.1, 5.8, and 3.7 visits per plot, respectively (Fig. 3). 'Mickylee' and 'Intruder' were not significantly different but both had greater visitation than 'Companion'. An interaction between sampling time and cultivar occurred on 22 Sept. During the first sampling time, 'SP-1' had

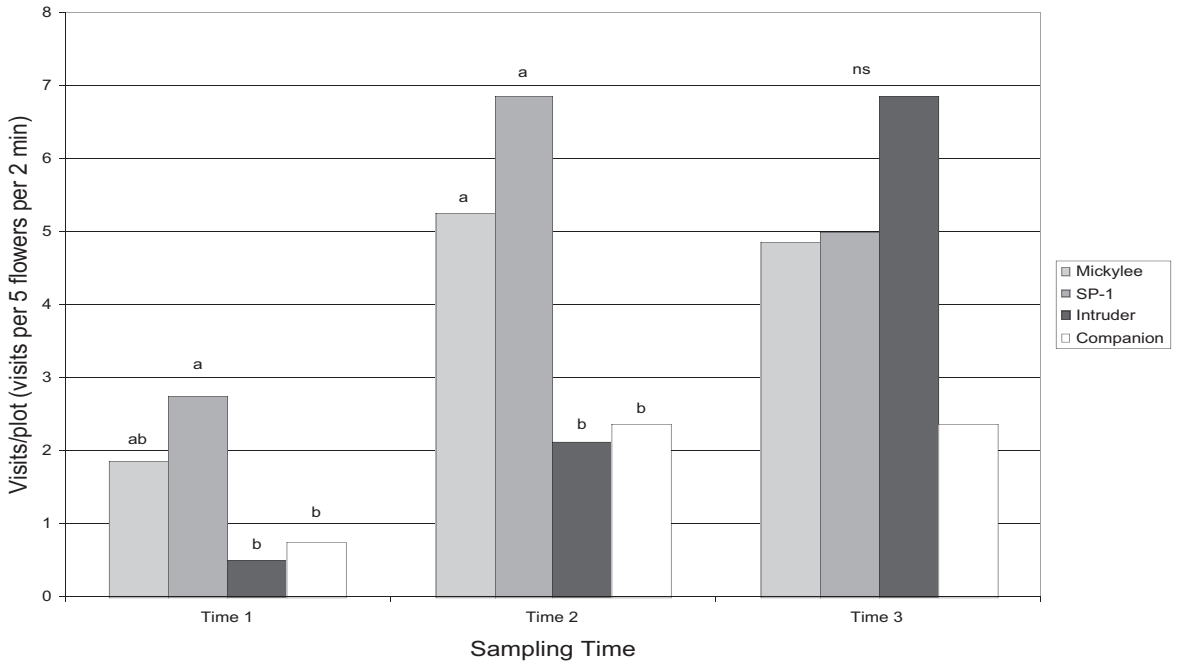

Fig. 4. Interaction effect of cultivar and time on pollinator visitation to staminate watermelon flowers at Quincy, FL, on 23 Sept. 2006. Visitation means are to be compared within sample time. Means not followed by the same letter are significantly different at $P \leq 0.05$.

2.7 visits per plot, which was not greater than 'Mickylee' at 1.8 visits per plot but was greater than 'Companion' and 'Intruder' at 0.7 and 0.5 visits per plot, respectively (Fig. 4). 'Mickylee', 'Companion', and 'Intruder' were not significantly different. During the second sampling time, 'SP-1' had 6.8 visits per plot, which was similar to 'Mickylee' at 5.2 visits per plot; both had greater visitation than 'Companion' or 'Intruder', which had 2.3 and 2.1 visits per plot, respectively. 'Companion' and 'Intruder' were not significantly different. There was no significant difference between cultivars during the third sampling time. On 29 Sept. main effects did not influence pollinator visitation (Fig. 3). No data were taken from 'Companion' on 29 Sept. because it had ceased production of staminate flowers. Complete floral visitation data are shown in Figures 1 to 4.

Discussion

Either 'Mickylee', 'SP-1', or both received greater floral visitation than 'Companion' or 'Intruder'. Previous research has shown that staminate flower production by 'SP-1' is greater than that of 'Mickylee' or 'Companion', which was similar (Freeman and Olson, 2007). The number of flowers that were used in sampling was held constant in order to determine the relative attractiveness of each cultivar's staminate flowers. This research illustrates differential attractiveness between cultivars and ploidy levels. Visitation at the whole plant level for 'SP-1' could be higher than the other cultivars due to greater numbers of staminate flowers, but a staminate flower produced by 'SP-1' is not necessarily more attractive than a staminate flower produced by 'Mickylee'. Other researchers have reported differences in pollinator visitation between watermelon cultivars and between *Citrullus lanatus* and *Citrullus colocynthis,* which was attributed to nectar sugar concentration (Wolf et al., 1999). It has been shown that floral volatiles emitted from pollen are the most important close-range cues during foraging by honeybees; however, visual stimuli are important long-range cues (Pernal and Currie, 2002). 'Companion' has a nearly entire leaf with reduced lobes and produces staminate flowers with short peduncles. These factors tend to obstruct the view of staminate flowers produced by 'Companion', which may be why it was generally visited less than 'SP-1' and 'Mickylee'.

A diploid watermelon cultivar was preferred over the triploid on sampling dates where cultivar affected pollinator visitation. Triploid watermelon plants produce mostly non-viable, aborted pollen that may be covered with less pollenkitt than viable pollen produced on diploid flowers. Pollenkitt emits volatiles that are important in foraging decisions of pollinators. These volatiles are an indicator of pollen reward that is available in a flower, and reduced volatile emissions may indicate reduced reward (Dobson et al., 1996). A reduction in pollenkitt produced in triploid staminate flowers could represent reduced reward and result in flowers that are less attractive to pollinators. Previous research has shown that bumblebees preferentially foraged potato flowers that produced viable pollen over ones producing non-viable pollen, which may be due to differences in volatile emissions (Batra, 1993).

When the performances of multiple diploid watermelon pollenizer cultivars were compared, triploid watermelon yields from plots pollenized by 'Companion' were significantly less than plots pollenized by 'SP-1' or 'Mickylee'. The lower preference of 'Companion' may lead to less viable pollen transported by pollinators and thus less fruit on triploid plants. A diploid pollenizer cultivar with staminate flowers that are more attractive than triploid staminate flowers could increase the movement of viable pollen within a field and possibly increase seedless watermelon yield.

Literature Cited

Arndt, G.C., J.L. Rueda, H.M. Kidane-Mariam, and S.J. Peloquin. 1990. Pollen fertility in relation to open pollinated true seed production in potatoes. Amer. Potato J. 67:499–505.

Batra, S.W.T. 1993. Male-fertile potato flowers are selectively buzz-pollinated only by *Bombus terricola* Kirby in upstate New York. J. Kansas Ent. Soc. 66:252–254.

Butler, C.G. 1951. The importance of perfume in the discovery of food by the worker honeybee (*Apis mellifera* L.). Proc. Royal Soc. of London, Ser. B, 138:403–413.

von Frisch, K. 1967. The dance language and orientation of bees. Belknap Press, Cambridge, MA.

Dobson, H.E.M. 1991. Pollen and flower fragrances in pollination. Acta. Hort. 288:313–320.

Dobson, H.E.M., J. Bergstrom, G. Bergstrom, and I. Groth. 1987. Pollen and flower volatiles in two *Rosa* species. Phytochemistry 26:3171–3173.

Dobson, H.E.M., I. Groth, and G. Bergstrom. 1996. Pollen advertisement: Chemical contrasts between whole-flower and pollen odors. Amer. J. Bot. 83:877–885.

Free, J.B. 1993. Insect pollination of crops, 2nd ed. Academic, London.

Freeman, J.H., G.A. Miller, S.M. Olson, and W.M. Stall. 2007. Diploid watermelon pollenizer cultivars differ with respect to triploid watermelon yield. HortTechnology 17:518–522.

Freeman, J.H. and S.M. Olson. 2007. Characteristics of watermelon pollenizer cultivars for use in triploid production. Intl. J. Veg. Sci. (In press.)

von Frisch, K. 1967. The dance language and orientation of bees. Belknap Press, Cambridge, MA.

Kihara, H. 1951. Triploid watermelons. Proc. Amer. Soc. Hort. Sci. 58:217–230.

Maynard, D.N. and G.W. Elmstrom. 1992. Triploid watermelon production practices and varieties. Acta Hort. 318:169–173.

Olson, S.M., E.H. Simonne, W.M. Stall, P.D. Roberts, S.E. Webb, T.G. Taylor, and S.A. Smith. 2006. Cucurbit production in Florida, p. 191–237. In: S.M. Olson and E.H. Simonne (eds.). Vegetable production handbook for Florida. Univ. Fla. Coop. Ext. Serv. and Vance Publ., Lenexa, KS.

Pernal, S.F and R.W. Currie. 2002. Discrimination and preferences for pollen-based cues by foraging honeybees, *Apis mellifera* L. Animal Behaviour 63:369–390.

Walters, S.A. 2005. Honey bee pollination requirements for triploid watermelon. HortScience 40:1268–1270.

Wolf, S., Y. Lensky, and N. Paldi. 1999. Genetic variability in flower attractiveness to honeybees (*Apis mellifera* L.) within the genus *Citrullus*. HortScience 34:860–86.