significant and non significant, leads to a conclusion that the post applications of naptalam at 3.0 and 4.0 lb/acre with a crop oil may be phytotoxic. Also the application of naptalam post at 4.0 lb/acre without a crop oil may reduce crop vigor if it follows a pre treatment of bensulide (5.0 lb/acre) + naptalam (4.0 lb/acre). The tank mix of ethalfluralin + naptalam applied preemergence did not reduce crop vigor below that of ethalfluralin alone. The control of AMACH, POROL or RCHSC and ELEIN was good to excellent with ethalfluralin alone and was not affected by the addition of naptalam.

More research must be done to ascertain whether a tank mix of ethalfluralin + naptalam would be warranted with the presence of other broadleaf weeds and to conclusively pinpoint the interaction between pre and post applications of naptalam as to rate, crop oil, and tank-mixing with other herbicides.

Selected References

1. Federal State Market News Service. 1990. Vegetable Summary (1988-1989). Florida Dept of Agr. and Consumer Services. Tallahassee.
2. Locascio, S. J. and W. M. Stall. 1982. Pre and postemergence weed control in cucumber and squash. Proc. South. Weed Sci. Soc. 35:112-117.
3. Locascio, S. J. and W. M. Stall. 1989. Cucumber, squash and watermelon tolerance to selected herbicides. Proc South Weed Sci. Soc. 42:157(abst.)
4. Locascio, S. J., W. M. Stall, S. M. Olson and C. S. Vavrina. 1990. Watermelon production as influenced by herbicide combination and cultivation. Proc. Fla. State Hort. Soc. 102:332-335.
5. Losses due to Weeds Committee. 1984. Crop losses due to weeds in Canada and the United States. Special Report. Weed Sci. Soc. of Amer. Champaign, Ill.
6. Stall, W. M. 1990. Weed control in Florida vegetables. Chapt. 18:9-11. In: Florida Weed Control Guide. Fla Coop Ext. Serv. Univ. Fla. Gainesville.

Proc. Fla. State Hort. Soc. 103:130-133. 1990.

ATTRACTION OF HONEY BEES TO WATERMELON WITH BEE ATTRACTANT

GARY W. ELMSTROM
University of Florida, IFAS
Central Florida Research and Education Center
5336 University Avenue
Leesburg, FL 34748-8232

DONALD N. MAYNARD
University of Florida, IFAS
Gulf Coast Research and Education Center
5007 60th Street East
Bradenton, FL 34203-9324

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Abstract. **Two applications of a bee attractant (Bee-Scent) to watermelon, *Citrullus lanatus* (Thunb.) Matsum. & Nakai, were made on 5 farms in central and southwest Florida. Honey bee, *Apis melifera* L., activity following application was monitored and yield and fruit quality were determined. Increased honey bee activity was noted on only a few occasions. Total fruit yield was increased on one farm in central Florida and there was an apparent increase in early yield on all three farms in southwest Florida. Soluble solids content of mature fruit was not directly affected by treatment. Treatment increased the seed content of fruit from three of five farms.**

In Florida during the 1989-90 season, watermelons were harvested from 50,000 acres and had a value of over $45 million (2). On average, Florida produces 30 to 40% of the nation's watermelons. Triploid or seedless watermelons are becoming of increasingly important in Florida and the rest of the country, probably accounting for about 5% of the total acreage.

Florida Agricultural Experiment Station Journal Series No. N-00331. We would like to express our appreciation for the cooperation of growers Donald Bass, Grady Smith, and Bridges Barry in Lake and Sumter Counties and J. M. Cincotta and Hunsader Farms in southwest Florida.

The Cucurbitaceae, including watermelon, require insects for pollination and fruit set. Watermelons are predominantly monoecious, having separate male and female blossoms on the same plant. Since the transfer of an adequate amount of pollen is essential to ensure optimum seed number and fruit set, size, and shape, most commercial growers provide honey bee hives near production fields. Adlerz (1) found that female blossoms require a minimum of 8 honey bee visits for normal fruit development to take place and that the optimum time for honey bee visits was between 6:00 and 10:00 AM. Each seed in a fruit is the result of the fertilization of a single ovule by a male gamete from a single grain of pollen. It is estimated that for optimum watermelon fruit set, 1,000 grains of pollen need to be spread evenly over the 3 lobes of the stigma (6). Seed quality may also be improved when large pollen loads are available (7). When high pollen loads were available, seeds of zucchini (*Cucurbita pepo* L.) germinated more rapidly, exhibited greater growth as seedlings, and had greater reproductive output as adult plants than seeds resulting from low pollen loads. It is hypothesized that such differences in progeny vigor are due to differences in the vigor (growth rate) of the microgametophytes that sired the seeds (5). When pollen competition is intense, only the fastest growing pollen tubes achieve fertilization whereas both fast and slow growing pollen tubes achieve fertilization in the absence of pollen tube competition. Seed count varied from a low of 40 seeds per fruit with low pollen loads to approximately 300 seeds with high pollen loads.

Although triploid watermelons are essentially seedless, they do require pollination and pollen tube growth in order to induce fruit set. Since most pollen grains from triploid plants are sterile and do not germinate when transferred to the stigma, pollen must be obtained from diploid pollenizer plants located nearby for fruit set to be achieved.

Since the population of bees is of utmost importance, most growers locate beehives near to their commercial plantings. Although honey bees are attracted to watermelon flowers by odor, color, form, nectar supply, and pollen (3), there are a number of factors which affect the actual number of bees available for pollination. Bee activity is highly dependent upon temperature, sunlight, and wind speed. Blossoms on surrounding commercial crops and weeds may be more attractive to bees than the watermelon blossoms. Male blossoms on triploid plants have less pollen than their diploid counterparts and so are less attractive to bees.

A bee attractant evaluated on blooming pear, plum, apple, and cherry increased the number of foraging bees and increased fruit set between 5 and 44% (4). The object of these trials was to determine the effects of a bee attractant on honey bee activity, fruit set, early and total yield, and fruit quality in watermelon fields in central and southwest Florida.

Materials and Methods

Bee attractant (Bee-Scent) was applied in 3 commercial watermelon farms in central Florida, Leesburg area, and in three farms in southwest Florida, Bradenton area (Table 1). Bee-Scent is a liquid formulation containing 9% pheromone and 40% other natural attractants (Scentry, Inc, P. O. Box 426, Buckeye, AZ 85326). The precise composition is proprietary information not available to the authors. 'Crimson Sweet' was planted in all farms in central Florida and 'Royal Jubilee' was planted in southwest Florida. All of the farms had supplementary hives available for pollination. In each of the central Florida fields, an area 50 ft by 150 ft was treated and a similarly sized area at least 500 ft from the treated area was marked off as the check plot. In southwest Florida the size of each treated area was 26 ft by 100 ft. The check was located north or south of the treated plot so that it was not downwind. Attractant was applied after 3:00 PM at 2 quarts per acre in 15 gallons of water using a backpack sprayer. The first application was made 3 to 5 days after the initiation of female flowering and a second application was made within a week of the first. Applications were made between 15 and 21 Apr. in central Florida and between 5 and 25 Apr. in southwest Florida. Toward the center of the treated area 3 open blossoms, 2 male and 1 female, were selected and the number of honey bee visits within a 15-minute period was recorded. At least two 15-minute counts were made in each treated and each untreated plot. At the central Florida farms, open female flowers were tagged with the date of anthesis on the 2 days following each application. In central Florida, total yield was estimated by counting fruit 7 days prior to harvest. Ten fruit were randomly selected from each plot at harvest. The soluble solids content of the flesh was determined with a hand-held refractometer and the total number of seeds in each of the 10 fruit was determined. Prior to harvest in southwest Florida, the fruit were graded into 5 size categories with 1 being the smallest and 5 being the largest. Fruit weight and seed count were obtained from 6 melons selected at random from watermelons in each plot.

Table 1. Bee activity on the two days following application of bee attractant to watermelon in Central and Southwest Florida in Spring 1990.

Farm	Monitoring date	Temp. (°F)	Time	Bee counts[y] Attractant[z]	Check
		Central Florida			
Bass	12 April	55	10:15 AM	0	0
	13 April	65	10:00 AM	0	0
	16 April	70	11:00 AM	0	2
	17 April	75	9:30 AM	0	0
Barry	14 April	70	10:30 AM	3	0
	15 April	70	10:30 AM	2	3
	17 April	75	9:45 AM	8	0
	18 April	75	9:15 AM	2	1
Smith	16 April	75	9:45 AM	9	5
	17 April	75	9:00 AM	34	17
	19 April	80	8:45 AM	12	10
	20 April	80	9:45 AM	7	10
		Southwest Florida			
Hunsader	6 April	71	10:00 AM	4	9
	7 April	81	10:45 AM	23	19
	12 April	72	12:45 PM	17	34
	13 April	78	11:15 AM	3	4
Cincotta I	12 April	74	2:45 PM	9	10
	13 April	80	12:45 PM	9	6
	19 April	84	12:15 PM	6	5
	20 April	81	11:45 AM	6	7
Cincotta II	19 April	82	11:00 AM	5	11
	20 April	78	10:45 AM	11	8
	26 April	80	10:30 AM	21	20
	27 April	83	10:45 AM	7	6

[z]Honey bee visits to 3 flowers during two 15 min. periods were monitored on the 2 days following treatment with bee attractant (Bee-Scent) @ 2 qt/A in 15 gal. H_2O.
[y]Visits/3 flowers/30 min.

Results and Discussion

A summary of application dates and locations, times when bee activity was monitored, and weather information is provided in Table 1. Mid-morning temperatures on the days following the application of bee attractant ranged from 55° to 75°F in central Florida and from 70° to 84°F in southwest Florida, somewhat cool temperatures for that time of the year. Although bee activity is normally greatest between 8:00 and 10:00 AM, cool weather delayed maximum bee activity until later in the morning or even early afternoon. On the 2 days following application, honey bee visits were recorded when bee activity was determined to be the greatest.

Bee activity. Since there were no apparent differences in the number of visits to male and female blossoms, the number of visits were combined over the 30-minute period of monitoring (Table 1). These numbers represent honey bee visits to 3 flowers over a 30-minute time period. Pollination can take place for 2 to 4 hours, therefore 3 and 6 visits to the 3 flowers in 30 min. provide the minimum of 8 visits per flower determined by Adlerz (1) to be necessary for normal fruit set. This minimum was obtained on most days in southwest Florida but on less than half the days in central Florida. The only time that increased bee activity was noted was at the Smith farm after the first application of attractant. In many cases monitors noted bee activity on flowers surrounding those selected for evaluation. It is possible that a better system for identifying bee activity such as monitoring more than 3 flowers or walking the plot and recording the number of bees observed is needed. Plot size may need to be increased so that scout bees would be more likely to detect the bee attractant.

Fruit yield. In central Florida, application of bee attractant increased the yield of watermelons on the Barry farm

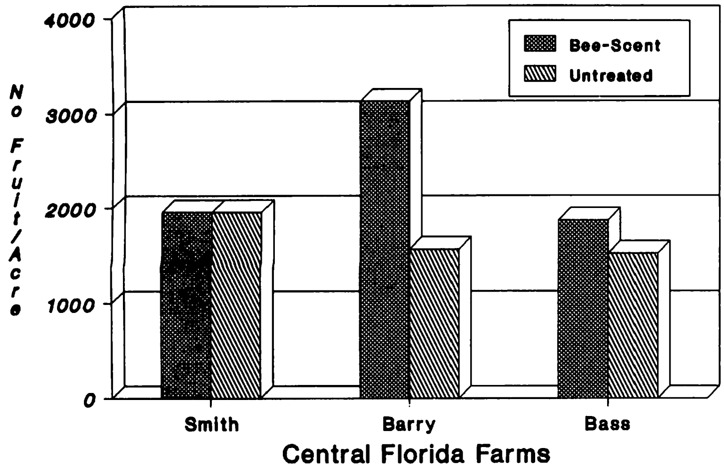

Fig. 1. Effect of bee attractant on total yield of watermelon on three farms in central Florida.

(Fig. 1). There was a slight increase in yield on the Bass farm and no different in yield on the Smith farm. Fruit in the Barry and Bass farms was setting at the time of treatment as evidenced by the fact that most of the tagged blossoms set; this was not the case in the Smith field. Although there were plenty of open female flowers, conditions were not right for fruit set. This could be the result of prior fruit set, unfavorable environmental conditions, or plant stress. All of these factors need to be considered in timing the application of bee attractants. Mean fruit weight was not affected by treatment (Fig. 2).

In southwest Florida, fruit were counted and grouped according to size on 11 May. There were no differences in total number of fruit but the fruit on the treated plants were larger (Fig. 3). Bee attractant may have been responsible for improved pollination and early fruit set; the small size fruit resulted from later flowering and set. On one farm, mean fruit weight was unaffected by treatment; on the other farm, fruit from treated plants were slightly larger (Fig. 2).

Fruit quality. On the Barry farm, the fruit from plants treated with attractant had a lower soluble solids content (Fig. 4). These fruit were on the same plants which pro-

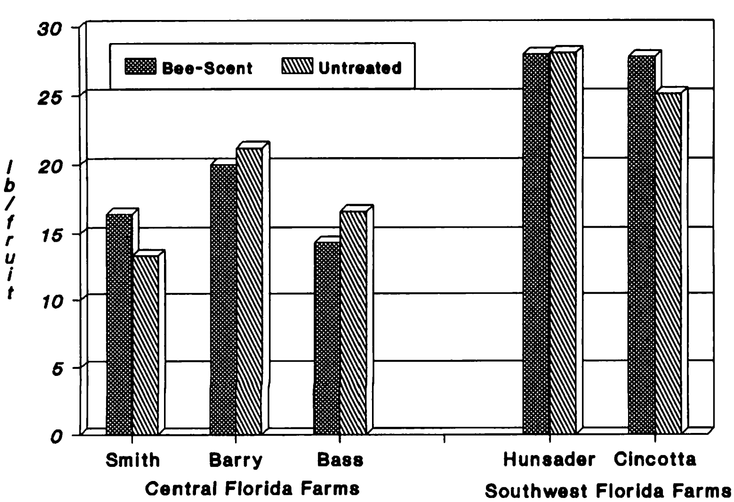

Fig. 2. Effect of bee attractant on fruit weight of watermelon from 5 farms in central and southwest Florida.

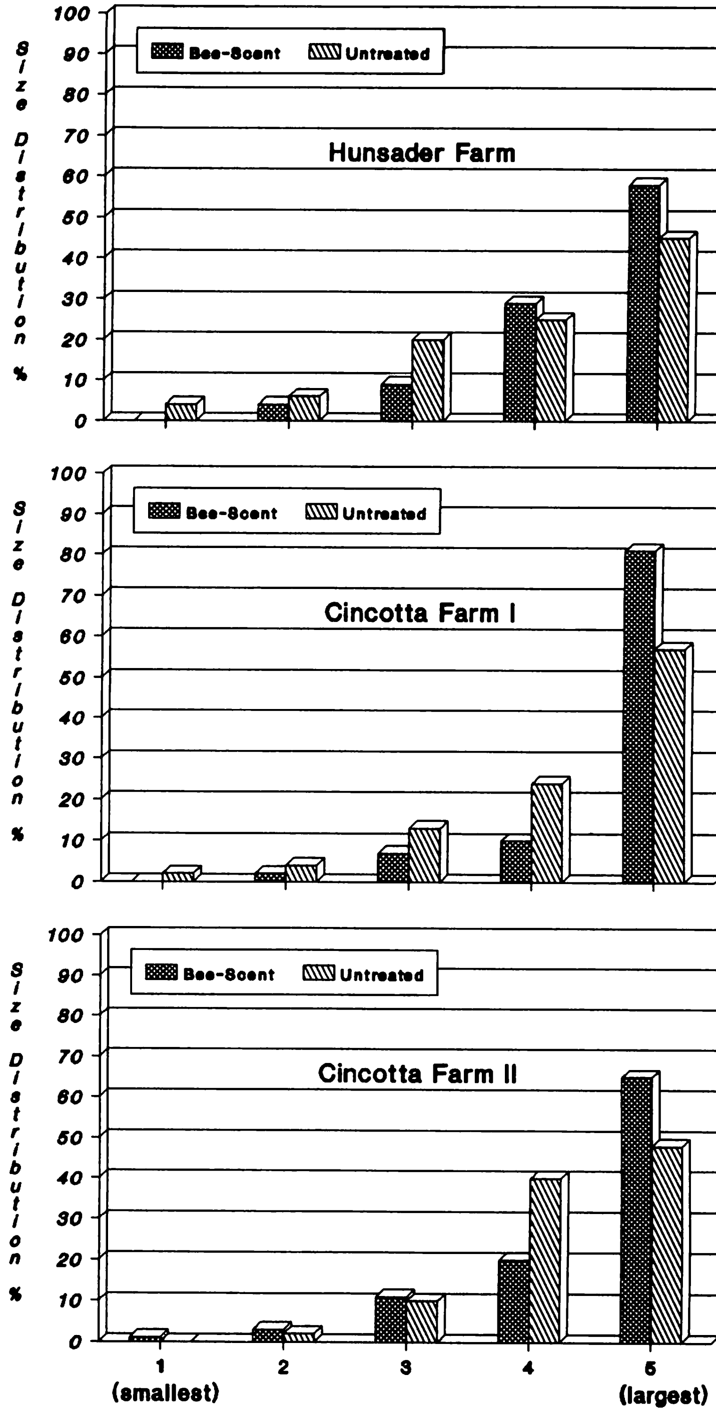

Fig. 3. Effect of bee attractant on fruit size distribution of watermelon from 3 farms in southwest Florida. Melons were graded into 5 size categories with 1 being the smallest and 5 the largest.

duced a higher yield than the untreated plants and their lower sugar content may have been the result of competition for a limited amount of photosynthate.

Compared with untreated vines, treated vines had fruit with more seeds on 3 farms, equal seed numbers on 1 farm, and slightly fewer seeds on another farm (Fig. 5). These results are inconclusive but timing of attractant application would be critical for a correlation between treatment and seed count. Incidence of hollow heart was recorded in fruit from the southwest Florida farms. It is possible that hollow heart in watermelon is related to pollina-

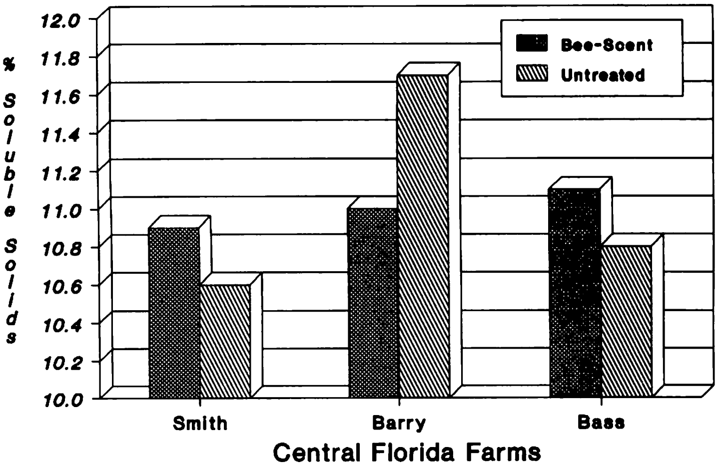

Fig. 4. Effect of bee attractant on the soluble solids content of watermelons from 3 farms in central Florida.

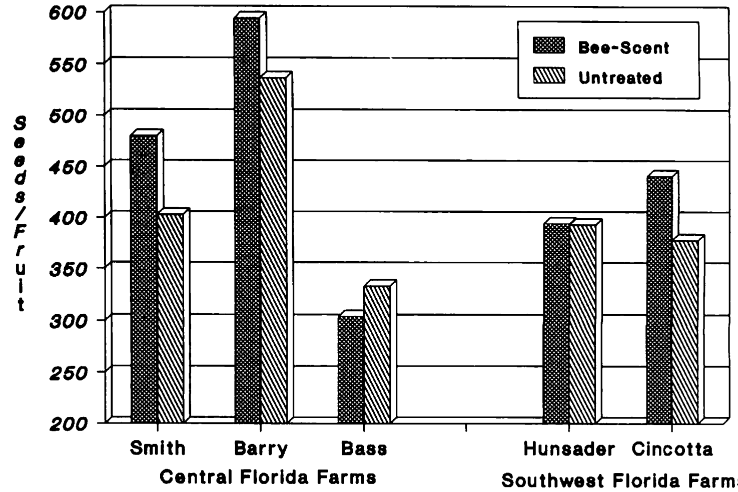

Fig. 5. Effect of bee attractant on the seed content of watermelons from 5 farms in central and southwest Florida.

tion/seed set. Fruit with hollow heart hd 350 seeds each whereas the average seed count of normal fruit was 418. Open flowers were not tagged in the southwest Florida fields so it was not known whether fruit were setting at the time of treatment. With improved timing of attractant application, it may be possible to increase seed content thereby reducing incidence of hollow heart.

The results from this preliminary work with a bee attractant give some indication that treatment may result in improved early and total yield of watermelon and increased seed yield. The use of bee attractants may be advantageous when one or more of the following circumstances exist:

1. An inadequate number of beehives are present;
2. Available hives have low bee populations;
3. Death of bees from pesticide misuse;
4. Cold, windy, or overcast weather;
5. Competing crops or weeds are nearby;
6. Lack of adequate viable pollen;
7. Improved seed yield or quality is necessary; and
8. Reduced incidence of hollow heart is required.

Additional research is needed on timing of application for cucurbits so that the attractant is available at the time fruit set will take place. The effect of size of the treated area on bee attraction needs to be determined. Better means of evaluating bee activity and the benefits from application should be developed.

Literature Cited

1. Adlerz, Warren C. 1966. Honey bee visit numbers and watermelon pollination. Proc. Fla. State Hort. Soc. 59:28-30.
2. Anonymous. 1990. Florida agricultural statistics. Vegetable summary 1989. Florida Crop and Livestock Reporting Service, Orlando, Florida.
3. Brett, Charles H. and M. J. Sullivan. 1972. Bee attraction to cucurbit flowers and pollination. NC Agr. Expt. Sta. Bull. 443.
4. Mayer, D. F., R. L. Britt, and J. D. Lunden. 1989. Evalutation of BeeScent® as a honey bee attractant. Amer. Bee J. 129:41-42.
5. Mulcahy, D. L. and G. B. Mulcahy. 1987. The effect of pollen competition. Amer. Scientist 75:44-50.
6. Sanford, M. T. 1988. Watermelon Pollination: Principles and Pointers, *In*. Proceedings 1988 Florida Watermelon Institute, Univ. of Fla. Veg. Crops Ext. Rpt. VEC 88-1.
7. Stephenson, A. G., J. A. Winson, and L. E. Davis. 1986. Effects of pollen load size on fruit maturation and sporophyte quality in zucchini. *In*: Biotechnology and Ecology of Pollen. Springer, New York.