POLLINATION OF MUSKMELONS, *CUCUMIS MELO* L. UNDER AIR INFLATED POLYETHYLENE BY HONEYBEES, *APIS MELLIFERA* L.

by

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ABSTRACT

Behavior and pollination effectiveness of honeybees, Apis mellifera L., were studied using muskmelons, Cucumis melo L., grown in an enclosed environment at Tucson, Arizona, in 1972.

Four groups of melon plants were grown in an air-inflated polyethylene greenhouse, with one group serving as a control. Blooms were shielded from bee visits by using gelatin capsules.

In the control group, blooms were shielded during the entire study. In a second group, blooms were shielded for the first 21 days. In a third, blooms were shielded 21 days after the appearance of the first female blooms, and the fourth group was open to bee visits during the entire experiment.

Plants whose blooms were shielded for the entire experiment produced no edible melons which indicated that pollination was not satisfactory. The production of those plants whose blooms were exposed at sometime during the experiment did not vary significantly. Seed counts, percent soluble solids and weights of melons indicated adequate pollination had taken place.

The maintenance of bee activity was enhanced by the presence of supplemental pollen cake. This pollen appeared as necessary as the attractive blooms to stimulate bee activity.

Carbon dioxide percentages within the greenhouse appeared to affect directly the soluble solids percentages in mature melons.

INTRODUCTION

Insects, especially honeybees, have been used in greenhouses for many years to facilitate pollination. Highly varied results have been observed, possibly due to differences in construction materials of the greenhouses.

Recently, the sophisticated sand culture techniques developed for use in greenhouses in arid regions of the world have led to the need for more efficient techniques for essential pollination of certain crops by insects.

This study was made to determine if bees would maintain themselves, visit blooms and successfully pollinate melons, Cucumis melo L., within an air inflated polyethylene greenhouse of the type currently used in the arid lands research.

LITERATURE REVIEW

Pollination by insects is essential in most curcurbits, including melons (Alex, 1957; and others). Other methods such as hand pollination that might obtain pollen transfer appear thus far to have been unsuccessful or impractical.

Self pollination of melons without insects was shown to be possible by Ivanoff (1947), although the results of his tests demonstrated no commercial application; efforts to produce melons without pollination by Rosa (1924) proved unsuccessful. Davis and Meinert (1965) showed that even perfect flowers needed some form and mechanical intervention for pollination to occur.

Hand pollination, the mechanical transfer of pollen with an instrument such as a camel's hair brush, has been attempted. Wolf and Harman (1942) reported a total of six melons obtained from 292 hand pollinations. Shemetkov (1960) estimated that to hand pollinate one hectare of cucumbers, Cucumis siteva L., it would require an impractical 300 man days. He estimated that the efficiency was from 35 to 42 percent. Melons without sufficient pollination have been shown to be malformed and poor in quality (Mann, 1953; Bohn and Davis, 1964).

Thrips and ladybugs were discussed as possible pollinators by McGregor and Todd (1952), although Tsyganov (1953) discounted this possibility, estimating one bee as being equivalent to 11,000 thrips.

These works suggest that there is still no practical substitute for insect pollinators. Honeybees and bumblebees work equally well in pollinating runner beans in greenhouses, according to Free and Racey (1968). Szabo (1969) showed that the bee, Megachile rotundata (F.), was partially successful in pollinating melons.

Bee Activity Within Closed Environments

Bohn and Davis (1964) claimed that bees orient by visible responses in their pollination activities. Bertholf (1931a) suggested that bee vision was similar to human vision in the visible spectrum, i.e., 540-550 nanometers; however, he suggested further (1931b) that their vision was nearly five times as acute near 350 nanometers in the ultraviolet spectrum than in the spectrum visible to humans. The UV response has been further demonstrated by electro-retinalgram recordings by Goldsmith (1960) and others. Hertz (1939) speculated that UV and blue light were complementary colors to bees and that light colored flowers reflect UV, but not white light. Stephen (1970) stated that "...fiberglass does not admit UV light of the necessary wavelengths." His observation was substantiated by Bertholf's 1931b work. No references were found in this literature review that related polarized light or other electromagnetic wave response to orientation behavior of bees confined in cages.

D'Aguilar, Bella and Lecomte (1967) reported that bees confined under glass had problems in detecting end panes and that they continually would fly against the ends of the greenhouse. These bees also spent more time nearer the hive than was considered "normal"; from

this one might infer that something other than identified light phenomena is used for orientation. The fruit set, however, appeared to be uniform at all distances from the hive. Praagh (1972) used a coarse mesh net to cover a flight cage which was apparently not visible to bees. This net appeared to offer broad visible boundaries to assist bees in determining the extent of the cage limits. He concluded that only a small proportion of the bees used in his indoor cage took part in foraging activities.

Stimulative feeding of bees to induce visits to specific blossoms within a greenhouse was attempted by Shemetkov (1957), though no conclusions were mentioned. Nevkryta (1953) attempted to entice bees to work by attracting them to blooms with various scents.

Shemektov (1960) sums up the knowledge of cage work in stating that despite the effectiveness of bee pollination, problems of their utilization have not yet been worked out. Bees still weaken and colonies perish in caged conditions. Though problems in colony maintenance were acknowledged in his work, few suggestions were offered for overcoming these problems.

THE MELON PLANT

Under greenhouse conditions, spacing and training of vines are important. Wolf and Harman (1942) suggested pruning of melon vines to one main and two auxiliary branches. This technique significantly increased hermaphroditic blooms on the cultivar "Hal's Best". Rosa (1924) also discussed "nipping" of vines; however, he offered no conclusion as to its value.

Plant spacing and melon production was under outdoor conditions studied by Pew (1952). He worked with six-foot rows planted in hills from 4 to 24 inches apart and concluded that 6 to 12 inch spacings were best. This was verified by Davis and Meinert (1965).

Small undeveloped melons may be observed at the base of the pistillate blossoms the day before the blooms open (Figure 1). These melons develop successfully only if pollen is transferred to the stigma of the bloom. Where melons are grown within an enclosure, pollinating insects must be present or the pistillate flowers must be pollinated by hand (Beattie and Doolittle, (1951). Successful pollination also depends upon pollen transfer being accomplished when the style is receptive and when pollen is available in sufficient amount.

Jones and Rosa (1928) described dehiscence as the longitudinal splitting of the anther lobes. The melon pollen, however, remained in masses in the open pollen sacs, apparently due to a characteristic oily film, and was not dispersed except by mechanical transfer. Honeybees are ideally suited for this pollen transfer because of their unique hairy bodies, social habits, and availability.

Seaton and Kremer (1939) showed that dehiscence of melon anthers could occur at any hour. Though 8 a.m. was reported as a mean time, dehiscence took place as early as 4 a.m. on warm days, however, blooms did not open at all on cool days. McGregor and Todd (1952) showed that low temperatures and high humidity delayed bloom opening significantly. McGregor and Todd (1953) further showed that bee activity began early, peaked at about 11 a.m. and ceased by about 5 p.m. Nectar

was collected until nearly 5 p.m., although pollen was available only until about 1 p.m. Mann (1953) showed that bee activity occurred about one hour later than reported by McGregor and Todd (1953). Seaton and Kremer (1939) studied effects of climatological factors on cucurbits and suggested that temperature was the most important factor, since anther dehiscence occurred at almost any hour with favorable temperature. Whitaker and Bohn (1952) demonstrated marked variations in the microclimate of the plant with corresponding variations in bee visits. Although temperatures of 35° to 40° C. increased bee mortality, their performance was equally good at these high temperatures. These observations differ from those made by McGregor and Todd (1952), although they reported that nectar was available until about 5 p.m. Seaton and Kremer (1939) showed that blooms opened and bees became active daily at dawn, when temperatures were from 20° to 25° C. (Figure 2, 3, and 4).

According to Whitaker and Davis (1962), most American cultivars are andromonoecious in character, with both staminate and hermaphroditic flowers on the same vine.

Mann and Robinson (1950) followed their pollination investigation with observations of fruit set. Their test showed that thinned vines set 60 to 70 percent of total hermaphroditic flowers. Most of these sets soon aborted despite successful pollination. This indicated that plant physiological factors determine the numbers of fruit maturing on vines. This mechanism apparently is still not understood at this writing. Mann (1953) showed a ratio of 53 hermaphroditic

Fig. 1. Female bloom on afternoon prior to day of opening--note development of inmature melon at base of bloom.

Fig. 2. Female bloom during early morning on day of flowering--note young undeveloped melon.

Fig. 3. Female bloom with gelatin capsule in place to prevent bee visits.

Fig. 4. Female bloom in full flower. This stage was readily visited by bees throughout the experiment.

Fig. 1. Female bloom prior to opening.

Fig. 2. Female bloom early morning.

Fig. 3. Bloom showing gelatin capsule in place.

Fig. 4. Blossom in full bloom.

blooms to 42 male blooms, as did McGregor and Todd (1952). They further reported that this ratio dropped as blooms set and fruit developed, reaching a level of 1 male to 10 hermaphroditic blossoms. Foster (1964) also observed that developing melons tend to restrict further setting of new fruit (Figure 7).

Levin, Kuehl and Carr (1968) compared techniques for estimating bee populations and establishing criteria for activity (Figure 5). These techniques included tagging 10 blossoms and watching them for 10 minute periods, counting numbers of blooms and observing the number of bees active on these blooms on each of three 50-foot rows three times during three 10 minute periods. No statistical differences were observed between any of the techniques used.

McGregor, Levin and Foster (1965) estimated that a bee visit every 15 minutes was desirable for maximum pollination. They also suggested that a count of one bee per 10 hermaphroditic flowers was necessary for maximum success (Figure 9).

METHODS AND MATERIALS

This research was conducted during 1972 at facilities of the Environmental Research Laboratories, University of Arizona, at the Tucson International Airport, Tucson, Arizona. The two subspecies of Cucumis melo L. grown were reticulatus, "Perlita" muskmelon; and inodorous, "Crenshaw", winter melon, respectively. The environment included an enclosed polyethylene greenhouse facility and sand culture, with honeybees used as pollinating agents.

The Greenhouse

A detailed description and discussion of the greenhouse facilities and the controlled environment used, is described by Jensen and Eisa (1972). Basically, the structure was a sheet of 10 mil Monsanto "602" polyethylene that was air inflated and supported by pressure produced by fans. An environment with pressures of from one to three atmospheres was thus created.

The tillable space in this house was approximately 1500 square feet. At the south end there were packed-column heat exchangers. These were low honeycomb-like stacks of corrugated asbestos (Asbesdek^{R}) through which fresh water was sprayed. Air circulation could be modified depending upon the requirements of a crop. Since the chamber was air inflated, there were no overhead supports thus eliminating shadows.

The plastic was sprayed with white lime and white glue to control and reduce radiant-energy penetration in a uniform manner.

The greenhouse environment was closed, lacking any significant exchange with outside air. The air flowed the length of the house, was deflected back through a central tunnel, and the process repeated, in an endless oval pattern. Because the cycle was closed, the same trapped air swept repeatedly through the moist packed column, becoming almost saturated. Thus the humidity was kept high reducing transpiration. The temperature also could be regulated within limits.

Two A-frame trellises eight feet across the base, extended along the length of the greenhouse (Figure 6). They were constructed of 3/4 inch conduit and consisted of eight, 10 foot sections, each of which were seven feet high.

Preliminary Observations

In order to determine whether a colony of honeybees could be maintained within this polyethylene structure, small, five-frame hives of bees, each called a "nucleus" or "nuc" in the beekeeping trade, were placed inside the greenhouse on February 8, 1972. Each hive was supplied with a pollen cake supplement that consisted of one part ground pollen and two parts sucrose. Terramycin^{R} and Fumagillin-B^{R} were added for prevention of disease. Water was supplied in two containers, one located near each nuc.

These bees performed quite well. After several days, few bees were seen flying to the plastic, and as time went by fewer bees were found dead along the edges of the greenhouse frame. During this time,

water gatherers were continually flying between the water jars and the hive in an apparently normal manner.

Egg laying and brood rearing within these hives was consistent with similar hives outside.

At one end of this facility were planted several Cassava plants, Manihot esculinta, which bees freely visited for nectar from the stem nectaries.

About March first a volunteer crop of London Rocket, Sisymbrium irio L., sprouted in the otherwise bare sand in the greenhouse. Because this plant was recognized as being attractive to bees its growth was encouraged and gave this portion of the experiment an added dimension. Caged bees have been reported as foraging somewhat normally on this plant (Spangler, 1971). The bees freely worked the London Rocket until the intense sun literally "burned up" the plants.

On April 13, one of the nucs showed symptoms of a failing queen and therefore was requeened. The new queen produced good egg patterns for several days, but these eggs hatched erratically. The hive was then moved outside and subsequently gained in weight. This indicated a thriving colony and suggested that the decline was due to some factor within the greenhouse. The second nuc remained in the greenhouse for several weeks until it was returned to the bee yard in fair condition.

Experimental Design

Seed samples of each of the varieties were obtained from Ferry Morse Seed Company in April 1972. On May 14, 100 seeds from each sample were planted, one-half in synthetic soil cubes and one-half in peat pots

containing a 50-50 mixture of vermiculite and sand. These plants were transplanted to their final locations within the greenhouse on June 18. They were set at 18 inch intervals alternately along the trellises. Each trellis thus accommodated 100 plants.

The plot design called for five random sets of 20 plants each. This technique allowed the establishment of a design which simplified the analyses of variable factors and permitted accurate interpretation where missing data might occur (LeClerg, Leonard, and Clark, 1962). Each lot of plants was further divided into four sub lots. The female blossoms in sub lot A (treatment 1) then were exposed to bee visits only during the first 21 days of the experiment. The female blooms of sub lot B (treatment 2) were covered to exclude bees throughout the entire experiment. Sub lot C (treatment 3), was exposed to bees for the entire experiment. Sub lot D (treatment 4) was exposed to bee visits after being covered for 21 days.

A complete mixture of chemical nutrients was used, prepared according to a standard formulation developed by the Environmental Research Laboratory of The University of Arizona. These nutrients were supplied in an automatic watering system for 10 minute periods six times per day, representing an application of one gallon of solution per plant per day (Figure 8).

As the plants grew, they were trained upward by synthetic twine supported from the top of the trellis. The plants were pruned to establish one runner as the terminal portion of each vine. All other growth was cut back, in most cases to the second node.

Fig. 5. Honeybee actively working a bloom. Activity of this type was observed from dawn to about 5:00 p.m. daily.

Fig. 6. Five frame bee hive nucleus showing placement half way along the trellis in greenhouse. Nuc is situated so that it would receive early morning sun, and have uniform access to plants in all directions.

Fig. 7. Young melon set three days after pollination. Stem growth and callous where bloom detached are visible.

Fig. 8. Maturing melons and fully automatic watering system used in the experiment. Nutrients were supplied by the automatic watering system to each plant.

Fig. 5. Honeybee working bloom.

Fig. 6. Nuc placement in greenhouse.

Fig. 7. Young melon set.

Fig. 8. Maturing melons and watering system.

On June 23, the first male blooms appeared. On June 26, the first female blooms appeared. At this time the bees were moved into the greenhouse. Within two weeks blooms were present on all plants of both varieties.

From preliminary observations it was determined that the best utilization of bees in the greenhouse was obtained when a young, unoriented field force of bees was used. To facilitate this, the nuc used in this experiment was made up of a selection of frames containing about 80 percent mature brood, and having a productive young queen. This nuc was moved from the apiary about 4 p.m. during the height of the bee flight activities, leaving many of the older field bees behind. This nuc was placed half-way along the trellis, facing east, to receive early morning sun exposure (Figure 6). During this experiment, there were no large congregations of disoriented bees observed on or near the plastic greenhouse covering.

A pollen cake supplement was kept under the lid of the nuc available to the bees at all times. This source of protein was taken freely at the rate of about one-half pound per week during the course of the experiment.

To prevent bee visits, the hermaphroditic blossoms on the appropriate plants were covered with size 00 gelatin capsules (Figure 3) each morning by dawn before bees became active. Gelatin capsules satisfactorily prevented access of bees to the style of the female portion of these flowers and with a minimum of effect on the plant; the bees were allowed to visit the male flowers on these plants.

Because the gelatin capsules were used, screens were not required on the plants, and thus there was not the additional variable that shading would have introduced.

Pollen samples were collected hourly from several blooms, and germination was tested on agar plates consisting of 10 percent sugar and 15 percent dextrose in distilled water. Germination was observed on agar plates from samples taken at hourly intervals from sun-up (5:30 a.m.) until 12 noon. Though most of the pollen was gone by 10 a.m., a few grains were found up until noon but none thereafter.

Bee activity among the blossoms was recorded on several occasions and detailed counts were made during one minute periods. Time-lapse photographs of blossoms were taken over a four day period, to record bee visits and blossom cycles.

Maturity of the muskmelons was judged by the formation of a thin abrasion crack completely encircling the stem where it attached to the fruit. This was termed the "full-slip" stage, Davis, et al. (1965). Melons were harvested as they reached this stage every morning following the covering of female blooms.

A detailed record was kept for each melon including weight, seed count and soluble solids. These data were recorded only in relation to particular plants, with no reference to the treatment each plant received.

Seed counts were used to measure and evaluate successful pollination. Acceptability and palatability were judged on the basis of soluble solids.

Measurement of the soluble solids was made by direct refractive index with a Carl Zeiss refractometer. The sample was taken midway from stem to blossom end and one-half way into the flesh of the fruit since this index varies in different locations within the melon. Since no objective criteria could be established for flavor, this method was not considered a valid characteristic. No record, therefore, was taken with reference to flavor or taste.

An analysis of variance was made on the data for melons harvested. Duncan multiple range tests were used to evaluate this analysis.

The last melons were harvested and the experiment was terminated on September 6, 1972.

RESULTS AND DISCUSSION

Bee activity within this closed system was judged similar to that found out of doors. Bees appeared to forage normally (Figure 11). At no time during the experiment was there a large number of bees observed on or near the plastic. Deaths at the far corners of the structure were extremely low.

The number of bee visits to blooms averaged 3 to 5 minutes per hermaphroditic bloom. Counts on 100 successive blooms showed from 10 to 12 honeybees per 100 blooms at any time during the active period. Ten bees per 100 hermaphroditic blooms was the criterion established by McGregor and Todd (1952), also Levin, et al. (1968) to achieve successful pollination. Time-lapse photographs of blossoms were taken and suggested that the three bees per five minutes average might be a valid estimate for the visitations which occurred.

The bees were always busy, some collecting water from the humidifying pads at the south end of the greenhouse, and foragers always were active. The few times the pollen supplement was not available represent the only periods when there were excessive numbers of bees clustered on the hive.

As the plants matured and began setting blooms, it became apparent that the cultural techniques employed were fairly well suited for the muskmelon "Perlita", but the pruning of the "Crenshaw" melons melons removed fruiting spurs which were not replaced until 12 to 15

inches of new growth developed. Due to the limited space alloted per plant, it was decided that fruit counts and data taking would be limited to the "Perlita" melons, leaving the "Crenshaw" melons for observations of bee activity but foregoing any quantitative data analysis on these.

During the entire experiment the blossoms were open and dehiscence had occurred by sun-up (Figure 4). Pollen germination began within 20 minutes on the agar plates regardless of the hour collected. Within one hour nearly 100 percent of these grains had germinated. Contrary to Mann's (1953) suggestion that bees removed only a portion of the pollen, virtually all pollen was removed from the blooms by noon. Unlike the reports of problems with glass and fiberglass greenhouses, the bees seemed to work well under the polyethylene.

On August 3, the first melons were harvested. Data collected included weight, seed count and soluble solids. Following compilation of these data, an analysis of variant was made of the data representing the total number of melons produced per vine (Table 1). By visual inspection, the control, (treatment 2), was determined significantly different; however, a Duncan's multiple range test was run to see whether this was the only varient (Appendix). The results of this test concluded that the means of treatments 1, 3, and 4 are probably closely related, i.e., not significantly different.

Further analysis of variance was run on the data tabulated for the seed counts, (Table 2), melon weights (Table 3) and soluble solid content (Table 4). The "F" values for these tests each indicate an almost homogeneous population (Appendix). It might be noted that even

Table I. Number of melons harvested per plant with blooms subjected to four separate pollination treatments within a polyethylene greenhouse, Tucson, Arizona, 1972.

Plant Number	Blooms exposed to bees during first 21 days of experiment	Blooms not exposed to bees during entire experiment	Blooms exposed to bees during entire experiment	Blooms covered for 21 days prior to permitting bee visits
1	5	0	5	2
2	5	0	3	3
3	2	1	3	1
4	5	0	3	6
5	6	1	5	5
6	1	2	4	3
7	6	0	4	3
8	3	0	5	6
9	4	0	5	4
10	5	0	3	4
11	-	0	2	-
12	-	-	2	-
Totals*	42	4	44	37
Averages**	4.20[a]	0.36[b]	3.66[a]	3.70[a]

* Harvest period was 34 days

** Means not followed by the same letter differ significantly at p = 0.01, Duncan's multiple range test

Table II. Number of seeds from melons produced from blooms subjected to pollination by honeybees for three different periods within a polyethylene greenhouse, Tucson, Arizona, 1972.

Blooms exposed to bees only during first 21 days of experiment	Blooms exposed to bees during entire experiment	Blooms covered for 21 days prior to permitting bee visits
541	502	341
574	489	380
609	430	430
459	575	575
492	389	552
588	459	706
500	463	449
516	652	543
626	451	643
565	449	384
628	543	636
426	643	527
517	384	383
374	636	558
463	655	602
515	577	546
654	505	458
308	436	651
287	598	590
589	544	531
587	410	542
516	405	671
559	400	639
312	497	722
467	647	
542	549	

Table II. Continued

Blooms exposed to bees only during first 21 days of experiment	Blooms exposed to bees during entire experiment	Blooms covered for 21 days prior to permitting bee visits
337	520	
506	517	
595	720	
514	612	
514	504	
495	625	
607		
558		
438		
435		
Number of melons examined:		
36	32	24
Average number seeds produced:		
505	524	544

Table III. Weights of individual melons produced from blooms subjected to pollination by honeybees for three different periods within a polyethylene greenhouse, Tucson, Arizona, 1972.

Blooms exposed to bees only during first 21 days of experiment	Blooms exposed to bees during entire experiment	Blooms covered for 21 days prior to permitting bee visits
30	34	17
40	58	33
72	72	41
80	49	56
96	46	69
35	41	88
38	56	50
66	69	66
56	47	60
58	46	40
54	40	40
69	58	72
40	34	38
65	39	42
55	38	72
42	42	54
12	70	49
57	54	64
41	49	56
51	46	40
82	48	64
61	35	68
48	49	56
77	44	52
25	79	56
33	69	61

Table III. Continued

Blooms exposed to bees only during first 21 days of experiment	Blooms exposed to bees during entire experiment	Blooms covered for 21 days prior to permitting bee visits
65	68	50
40	67	48
85	35	66
37	62	81
26	56	51
53	57	76
68	39	68
57	31	55
42	81	82
52	64	60
66	98	93
36	46	
37	40	
42	41	
44	75	
60	108	
	57	
	58	
	38	
	81	
Number of melons weighed:		
42	46	37
Average weight:		
52.2	54.7	57.7

Table IV. Per cent soluble solids of melons from blooms subjected to pollination by honeybees for three different periods within a polyethylene greenhouse, Tucson, Arizona, 1972.

Blooms exposed to bees only during first 21 days of experiment	Blooms exposed to bees during entire experiment	Blooms covered for 21 days prior to permitting bee visits
7.1	10.0	10.5
7.1	12.0	12.5
6.0	13.5	5.0
10.5	5.0	7.0
13.5	7.0	8.1
8.5	8.5	8.0
8.0	8.0	10.0
8.5	7.5	10.0
8.5	8.5	12.5
8.0	8.0	9.5
9.5	10.0	9.0
7.5	10.5	9.5
7.5	10.0	6.0
8.0	10.0	10.0
8.0	7.0	7.0
7.5	7.5	7.5
8.5	7.5	7.5
7.0	9.5	12.0
9.0	9.5	9.5
6.5	11.5	10.0
12.0	7.0	5.5
10.0	9.0	9.5
6.5	5.5	10.0
3.0	8.0	7.5
13.0	7.0	7.0
13.0	8.0	11.5
11.5	10.0	11.0

Table IV. Continued

Blooms exposed to bees only during first 21 days of experiment	Blooms exposed to bees during entire experiment	Blooms covered for 21 days prior to permitting bee visits
8.0	6.0	10.5
8.0	11.0	9.0
7.5	11.5	9.0
7.5	7.0	8.5
7.5	7.0	10.0
8.0	11.0	12.0
9.5	10.0	8.5
8.5	11.0	9.0
8.0	5.5	11.5
8.5	5.0	10.5
11.5	8.0	
10.5	9.0	
8.5	10.0	
7.5	9.0	
6.0	10.0	
	8.5	
	7.5	
Number of melons tested:		
42	44	37
Average per cent soluble solids:		
8.5	8.6	9.2

though melons were harvested from the control (treatment 2), they were malformed and in two cases the seed chamber was rotted, and no significant data could be obtained from these melons.

McGregor and Todd (1953) and Bohn and Davis (1964) suggest a guide of 400 developed seeds per melon as an estimate for satisfactory pollination of blossoms. Seed counts from treatments 1, 3 and 4 ranged from 426 to 720 with means of over 500 (Table 2), indicating adequate pollination as evaluated by this method.

The testing of pollination in terms of eating quality was undertaken by Currence and Larson (1941). The refractive index or measure of the soluble solids by means of a refractometer was shown to be the most likely and reliable method. Results of this experiment also showed little relationship between melon flavor acceptability and the percent soluble solid. Flavor seems to be a highly personal matter without objective criteria. Acceptability of flavor did not seem to be related to increase in soluble solids contest.

The soluble solid data (Table 4) indicated that the first set melons are possibly the "sweetest", rather than the melons from the crown blooms (McGregor and Todd, 1953), the later sets being victims of "plant fatigue." Further research in the area should be considered before any conclusions are drawn.

During the third week in August, gas burners were operated to increase the carbon dioxide content within the greenhouse. The resulting carbon dioxide content of the atmosphere increased from 100 to 200 ppm to near 600 ppm. The content of soluble solids, which had been

running at about 8 percent in mature melons, increased to levels close to 12 percent and remained at this level for the rest of the experiment (Table 4). Prior to the use of the gas burners the carbon dioxide in the air decreased after sunrise as it was rapidly utilized during photosynthesis. The activities of the bees did not appear to be affected by the increase of carbon dioxide.

Changes in temperature, though often extreme, did not appear to affect the bees in any way.

Jensen and Teran (1970), showed a need to control Penicillium infections during tests at Puerto Penasco, Sonora, Mexico, and used Benlate^{R}, which was effective in preliminary tests. During this experiment several larger melons became the victims of Penicillium infections and did not mature properly. On August 15, two plants died, apparently due to mechanical injury and from inoculation with Penicillium spp. Plant exhaustion may have played a significant role here also. Plant exhaustion was reported to be a direct contribution to a second crop failure by D'Aguilar et al. (1967) in tests on squash, C. pepo, in greenhouses.

In concurrence with van Praagh (1972), there were no problems with swarming, however, brood was continuously being raised as long as pollen supplement was fed. The field force of bees appeared to work effectively throughout the experiment.

Fig. 9. Each plant with blooms exposed to bee visits produced an average of over three melons.

Fig. 10. A close up of maturing melons. These, if left alone, will fall free from the vine at that time.

Fig. 11. A honeybee packing pollen on a melon blossom. Pollen collecting and pollinating activities were judged to be identical to those observed under open field conditions.

Fig. 9. Average of over three melons per plant.

Fig. 10. Close up maturing melons.

Fig. 11. Honeybee packing pollen.

CONCLUSION

Honeybees, Apis mellifera L., successfully pollinated melons, Cucumis melo L., in polyethylene greenhouse during research conducted at Tucson, Arizona, in 1972.

A five-frame hive of bees was maintained within an air inflated 10 mil polyethylene plastic greenhouse for 60 days. Melons were successfully produced from blooms which were exposed to bee visits. Blooms under identical conditions but shielded from bee visits produced no edible melons, indicating that pollination was likely not satisfactory.

The overall bee activity resembled that seen under open field conditions. Pollen cake was provided to maintain colony strength.

The use of honeybees under polyethylene appears to be a practical and easy method of pollinating greenhouse crops. At no time during this work were there any major problems encountered with the bees.

Seed counts, melon weights and soluble solid contents taken from fruit produced from unshielded blooms showed homogeneous relationships throughout the tests.

An increase in carbon dioxide percentage within the environment probably increased the percent soluble solid content of the mature melons without appearing to affect the bee activity.

APPENDIX

ANALYSIS OF VARIANCE TABLES

Analysis of Variance of Total Melons Produced and Accompanying Duncan's Multiple Range Test

Source	Sum of Squares	DF	Mean Square	F
Main Effect	100.98	3	33.65	19.04
Deviation	68.93	39	17.67	
Total	169.91	42		

"P" Value (1%)	2	3	4
SSR	3.825	3.988	4.098
LSR	1.551	1.6167	1.6613

Analysis of Variance of Melons from Vines Pollinated by Honeybees

Source	Sum of Squares	DF	Mean Square	F
Main Effect	1.85208	2	0.92604	0.41722
Deviation	64.36667	29	2.21954	N.S.
Total	66.21875	31		

Analysis of Variance of Seed Counts from Melons Pollinated by Honeybees

Source	Sum of Squares	DF	Mean Square	F
Main Effect	21258.0	2	10629.0	1.0
Deviation	841656.0	89	9456.0	N.S.
Total	862914.0	91		

Analysis of Variance of Soluble Solids of
Melons Pollinated by Honeybees

Source	Sum of Squares	DF	Mean Square	F
Main Effect	10.300	2	5.150	1.320
Deviation	468.070	120	3.900	N.S.
Total	478.37	122		

Analysis of Variance of Weights (in Ounces)
from Melons Pollinated by Honeybees

Source	Sum of Squares	DF	Mean Square	F
Main Effect	587.13767	2	293.56883	1.00116
Deviation	35773.61433	122	293.22634	N.S.
Total	36360.752	124		

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