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EFFECT OF HONEYBEE ACTIVITY ON THE CROSS-POLLINATION OF MALE-STERILE SUNFLOWERS

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SUMMARY

Pollinator activity was observed and seed set determined in a block of male-sterile sunflowers surrounded by pollen-bearing sunflowers on the Darling Downs, Queensland.

Honeybees appeared to be the only insects playing a significant role in pollination. More visits were paid to pollen-bearing flowerheads (5.75 per head per hour) than to male-sterile flowerheads (0.45 per head per hour). Visits to both types were usually brief, most lasting less than 1 minute. Such behaviour is conducive to cross-pollination.

No seed set occurred in bagged male-sterile heads, showing that seed set in open male-sterile heads was dependent on cross-pollination. A mean level of 59.1% seed set occurred in open male-sterile heads following an average of 36 bee visits per head; 92.4% seed set occurred in open pollen-bearing heads following 460 bee visits per head.

I. INTRODUCTION

Previous work (Radford and Rhodes 1978) demonstrated no lack of pollinating honeybees in a sunflower crop at a site on the Darling Downs expected to have a shortage.

The aim of this work was to relate levels of honeybee activity to levels of cross-pollination in male-sterile (non pollen-bearing) sunflowers. A block of male-sterile sunflowers was grown in the middle of a crop of pollen-bearing sunflowers. Levels of honeybee activity were determined, and seed set was used as a measure of cross-pollination.

The use of male-sterile sunflowers demonstrates not only the level of cross-pollination to be expected in male-sterile cultivars (used for breeding hybrids) and in highly self-incompatible cultivars but also the potential level of cross-pollination in self-compatible cultivars.

II. MATERIALS AND METHODS

A block of male-sterile sunflowers cv. CMS HA 60 approximately 18 m square was sown in the centre of a 7 ha crop of pollen-bearing sunflowers cv. Sunfola 68-2 (derived from Peredovik 6296). Both the block and the crop were sown on 22 October 1974 at the same seeding rate. The edges of the block and the crop were approximately 1 m apart.

During flowering, 30 min observations of honeybee visits to three adjacent flowerheads were made simultaneously at four sites: the middle and edge of the male-sterile block and the middle and edge (beside the block) of the crop; 24 such simultaneous observations were made over a period of several days (table 1). Observation data at each site consisted of number of honeybee visits to the three adjacent flowerheads and the duration of individual visits to flowerheads. Further 15 min observations were used for additional data on the duration of visits.

Twelve CMS HA 60 and 12 Sunfola 68-2 heads were bagged prior to flowering. On 11 February 1975, the following heads were harvested: 8 CMS HA 60 heads with intact bags, 8 Sunfola 68-2 heads with intact bags, 8 open Sunfola 68-2 heads and 32 open CMS HA 60 heads. The 32 CMS HA 60 heads consisted of sets of 8 from the north, south, east and west sides of the block, with individual heads in each set taken at 1 m intervals from the edge to the middle of the block. Final plant height from ground level to the centre of the head was determined on 50 plants of each cultivar.

TABLE 1

OBSERVATION TIMES AND NUMBERS OF HONEYBEE VISITS TO THREE ADJACENT FLOWERHEADS

Observation Time		No. of Bee Visits to Three Adjacent Flowerheads			
		Male-Sterile Block		Surrounding Crop	
Date	Time Period	Middle	Edge	Edge (Near Block)	Middle
3 Jan 75	10.00–10.30 a.m.	0	0	0	5
	10.40–11.10 a.m.	0	0	6	12
	11.10–11.40 a.m.	0	0	1	15
6 Jan 75	10.00–10.30 a.m.	0	3	6	28
	10.30–11.00 a.m.	0	0	11	21
	11.00–11.30 a.m.	1	0	21	16
	11.45–12.15 p.m.	0	0	9	4
	12.15–12.45 p.m.	0	3	18	14
	12.45– 1.15 p.m.	0	2	13	7
7 Jan 75	8.10– 8.40 a.m.	1	3	1	0
	8.45– 9.15 a.m.	0	0	4	2
	9.20– 9.50 a.m.	0	0	0	2
	9.55–10.25 a.m.	0	0	1	3
9 Jan 75	9.55–10.25 a.m.	0	0	0	0
	10.30–11.00 a.m.	0	0	7	3
	11.05–11.35 a.m.	1	0	9	8
	11.40–12.10 p.m.	1	2	12	6
	12.15–12.45 p.m.	0	1	15	6
10 Jan 75 . .	9.55–10.25 a.m.	1	0	14	8
	10.30–11.00 a.m.	0	2	21	3
	11.05–11.35 a.m.	1	3	7	13
	11.40–12.10 p.m.	1	2	11	9
	12.15–12.45 p.m.	0	1	8	11
	12.50– 1.20 p.m.	2	1	12	11
Means (converted to mean number of visits per head per hour)		0·25	0·64	5·75	5·75

L.S.D. for significant differences among means: 1·71 (5%)
2·27 (1%)

Heads were individually handthreshed and the achenes fractionated in a "General' seed blower (Model "ER") set at full capacity. The fraction which failed to blow over the inverted U-tube contained well-developed seeds and seed set was 100%. The fraction blown away contained either no seed or very light seeds. The proportion containing light seeds was determined from subsamples of 50 achenes, which were dissected. Total seed set for each head was then calculated.

III. RESULTS

Both cultivars were in flower during the period 30 December 1974 to 12 January 1975, but the mean flowering time of individual heads of both cultivars was 8 days. Growth was less vigorous in CMS HA 60 (mean plant height: 89 cm) than in Sunfola 68-2 (mean plant height: 111 cm).

Number of honeybee visits

Honeybees were the only insects carrying out significant pollination activity during the observation periods.

The number of honeybee visits to Sunfola 68-2 heads significantly exceeded the number to CMS HA 60 heads (table 1). Sunfola 68-2 may have been more attractive to bees due to its pollen or its taller plants with larger flowerheads. Its more vigorous growth could also have resulted in greater nectar production or more attractive nectar.

Mean visitation rates were not significantly different at the middle and edge of the male-sterile block (table 1) averaging 0·45 visits per head per hour. This represents approximately 4·5 visits per head per day and a total of 36 visits per head during flowering.

Duration of honeybee visits

Mean duration of individual honeybee visits to flowerheads was 33·5 s in CMS HA 60 and 49·5 s in Sunfola 68-2. The frequency distribution of duration of individual visits to the flowerheads was, however, strongly skew (figure 1). Most visits to CMS HA 60 heads were extremely brief, 81% lasting less than 1 min and 61% of these lasting 10 s or less. Most visits to Sunfola 68-2 heads were also brief, 72% lasting less than 1 min and 44% of these lasting 10 s or less.

Seed set in bagged and open heads

Bagged CMS HA 60 heads set no seed, demonstrating there was no apomixis or breakdown of male-sterility and there was a need in the male-sterile block for an external agent of cross-pollination. Seed set in bagged Sunfola 68-2 heads was only 6·1%, demonstrating a need for an external agent of self and cross-pollination.

There were no significant differences in the seed set of open heads on the north, south, east and west sides of the male-sterile block; nor were there differences in seed set from the edge to the middle of the block. This indicates that cross-pollination was uniform in all directions over a distance of 7 m from the nearest pollen source. Mean seed set in open CMS HA 60 heads was 59·1% and in open Sunfola 68-2 heads 92·4%. Actual numbers of seeds set are shown in table 2 together with calculated numbers of seeds set per honeybee visit.

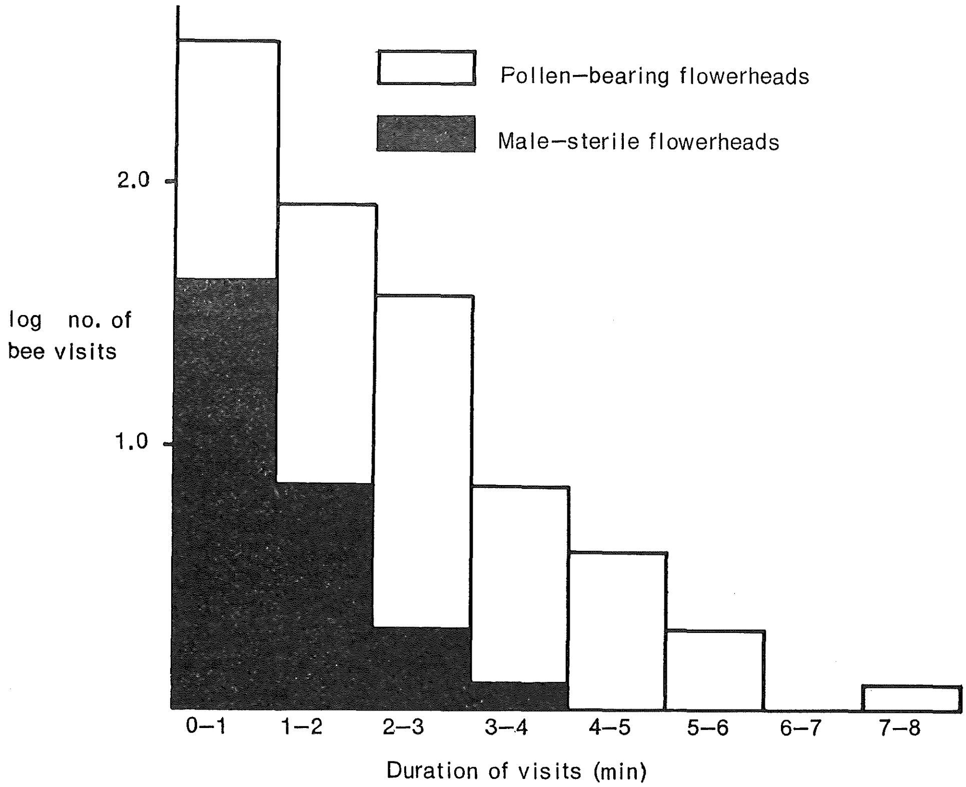

Figure 1. Frequency distribution of duration of individual honeybee visits to flowerheads.

TABLE 2

SEED SET IN CMS HA 60 AND SUNFOLA 68–2 IN RELATION TO HONEYBEE VISITS

Measurement	Cultivar	
	CMS HA 60	Sunfola 68–2
Mean no. of seeds set per head:		
Open heads	453	678
Bagged heads	0	44
∴ Mean no. of seeds set in open heads by external pollinating agents	453	634
Mean total no. of honeybee visits per open head	36	460
∴ Mean no. of seeds set per honeybee visit	12·6	1·4

IV. DISCUSSION

The entire 59·1% seed set in open male-sterile heads must be attributed to fertilization by pollen from the surrounding Sunfola 68-2 heads. The only pollinators observed were honeybees, and their behavioural pattern among flowerheads was ideally suited to the accomplishment of cross-pollination. Bees made an average of 36 visits to each male-sterile head during flowering, and if they were the only pollinators 12·6 male-sterile florets were cross-pollinated during each 33·5 s visit.

Other agents of cross-pollination may, however, have been present. Putt (1940) considered that sunflower was not wind-pollinated to any large extent, but attributed an increase in seed set from 11% under paper bags to 27% under tiffany bags to cross-pollination by wind. In the present trial, wind may have been an abnormally effective agent of cross-pollination due to the height advantage of donor over recipient heads, but no variation in seed set with distance from pollen source was detected. Wind could have acted as a joint agent of cross-pollination with honeybees by continuing to transport pollen dislodged from airborne bees. Nocturnal insects can also effect cross-pollination (Arnason 1966). Low populations of moths (3·9 per 100 flowering heads) have been observed on sunflower heads at night on the Darling Downs (Radford, unpublished), but their behavioural pattern did not appear well suited to cross-pollination.

Mean bee populations during the day (calculated) were 0·4 per 100 male-sterile heads and 7·9 per 100 pollen-bearing heads. A population of 7·9 bees per 100 pollen-bearing heads resulted in a satisfactory level of seed set for cropping purposes (92·4%). A population of 0·4 bees per 100 male-sterile heads resulted in unsatisfactory seed set (59·1%), but despite the low population a majority of the male-sterile florets set seed. Higher seed set would not result in a proportional increase in commercial yield due to compensatory reduction in seed size. Furthermore, most seedless achenes occur at the centres of heads (Free and Simpson 1964) where even when seed is set the achenes rarely contribute to commercial yield.

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