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Influence of Distance from Pollen Plant on Seed Produced by Male-Sterile Cotton

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ABSTRACT

Because of increasing interest in hybrid cotton, *Gossypium hirsutum* L., a study was made in southern Arizona in 1973 and 1974 to determine a planting pattern of pollinator and male-sterile rows that would give satisfactory yields of hybrid seed. In 1973 two rows of pollen plants were alternated with 14 rows of male-sterile plants. The two male-sterile rows closest to the pollen plants produced 49% more seeds per flower than were produced in the remaining male-sterile rows. In 1974 an alternating pattern of 2 rows of pollen parents and 6 rows of male-sterile parents was planted in 12 replications. There were no significant differences in number of seeds produced per flower among these male-sterile rows. In both years the seeds were a higher percentage of the total boll weight in bolls from the male sterile plants than in bolls from the pollen plants (68.2 to 60.6 in 1973 and 68.2 to 62.0 in 1974).

In both years production of hybrid seed was satisfactory. The male-sterile plants produced 98% and 79% as many seeds per flower as the pollen plants in 1973 and 1974, respectively. The mean number of bees observed visiting cotton flowers at any given time varied from 0.45 to 10.13 per 100 flowers. Honey bees (*Apis mellifera* L.) made 38% of the total bee visits in 1973 and 84% in 1974.

Additional index words: **Hybrid cotton, Pollination, Bees, *Gossypium* spp.**

SINCE the development of a stable male-sterile cotton using the *Gossypium hirsutum* L. chromosome complement in *G. harknessii* Brandegee cytoplasm by Vesta Meyer (1973), interest in developing hybrid cotton has accelerated. Cotton breeders are currently attempting to developing hybrid cotton in Arizona, New Mexico, Texas, Georgia, as well as in several foreign countries.

Cotton pollen is heavy and must be transferred from flower to flower by pollinating agents other than wind currents if male-sterile flowers are to produce seed. Normally this agent is an insect, although in India hand pollination has been used to produce hybrid cotton on a large scale despite the high cost of this method (Srinivasan et al., 1972).

If hybrid cotton seed is to be produced commercially in the USA, bees are the most logical pollinating agents. Therefore, studies were undertaken in 1973 and 1974 to determine the effect of distance from the pollen rows on seed production of male-sterile flowers when bee populations were relatively high.

METHODS

The cotton was grown in small commercial fields on the Papago Indian Reservation near San Xavier, Arizona and managed much like other fields except for the different planting patterns.

The male-sterile cotton used was on a 'Stoneville 213' background (Meyer, 1973). The pollen parent was 'Superokra' in 1973 and Stoneville 213 in 1974.

No insecticides were applied in either 1973 or 1974 because until 1972 no cotton had been grown in the area for many years. However, pink bollworm, *Pectinophora gossypiella* (Saunders), eventually invaded the area and caused damage to bolls setting after the first week of August in 1974.

In 1973, a single replication was made in an alternating pattern of 2 rows of male-fertile and 14 rows of male-sterile plants. This planting was adjacent to other combinations of male-sterile and pollen plants. One hundred flowers were tagged weekly for 8 weeks on both of the pollen rows and on each of the first seven male-sterile rows. Bolls were collected from all the tagged flowers that set bolls, the seeds counted, and the raw cotton weighed.

In 1974, 12 replications were planted. Each replication consisted of six 402-m long field rows of male-sterile plants. Two rows of pollen plants were planted between each replication and also on each border so that no male-sterile plant was more than 3 rows (3 m) from a pollen plant.

Twenty-five flowers were tagged in each row in 6 of the replications during the 1st, 3rd, 5th, and 7th weeks of bloom, while flowers in the other 6 replications were tagged the 2nd, 4th, and 6th weeks. However, flowers appearing after 10 August were not included in the 1974 analysis, because a combination of drought and pink bollworm damage greatly reduced the development of the bolls set after this date. Therefore, the seed set was calculated from flowers that opened during the first 4 weeks of bloom or from 14 July to 10 Aug. Otherwise, the data collected were the same as in 1973.

Previous studies have shown that in the test area more than 80% of the bolls are set during the first 4 weeks after heavy flowering starts. Bee visits were determined by an observer walking slowly through the field and counting the bees entering the open cotton flowers (McGregor, 1959). In this method, bee visits are given as percentage of total flowers observed. Thus, if 15 bees were seen in 300 flowers by the observer, at any one time, the visitation rate would be 5%.

RESULTS AND DISCUSSION

In 1973, the percent set of early flowers was greatest in the male-sterile row adjacent to the pollen plants and declined as row distance increased from the pollen plant. The male-sterile flowers in the first and second row closest to the pollen parent produced 49% more seeds per flower and 42% more seeds per boll than was produced by flowers 3 to 7 rows from the pollen source (Table 1).

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Table 1. Boll set, seed set per boll, and percent seed weight per boll on male sterile plants with increasing distance from the pollen plant; San Xavier, Ariz., 1973.

Rows from closest pollinator plant	Flowers setting bolls		Seeds per boll		
	7 July–4 August	5 August–2 September	Wt.	No.	Seed wt/boll wt
	% and 95% CL*		g		%
0 (Pollinator)	64.4 (±6.3)	21.8 (±4.0)	1.92	20.06	60.6 d
1	76.0 (±9.7)	35.4 (±4.8)	2.26	21.95	69.3 a
2	49.0 (±7.0)	48.0 (±4.9)	2.22	20.85	69.4 a
3	35.1 (±6.0)	42.0 (±4.8)	1.67	17.12	69.3 a
4	58.1 (±6.3)	43.4 (±4.9)	1.70	15.54	68.6 ab
5	43.9 (±6.4)	20.1 (±4.1)	1.50	14.33	69.2 a
6	66.8 (±5.6)	45.8 (±4.5)	1.45	13.52	65.1 c
7	45.5 (±6.4)	44.8 (±4.9)	1.67	14.93	66.3 bc
Avg. rows 1-7	53.5	39.9	1.78†	16.60‡	68.2*

* Means followed by the same letter do not differ significantly at the 5% level. CL* = 95% confidence limits. † Significant rank correlation (rows 1-7).
‡ Highly significant rank correlation (rows 1-7).

Table 2. Influence of distance from pollen parent on seed produced by male-sterile cotton plants; San Xavier, Ariz., 1973.

Week of main bloom and date flower tagged	Seeds produced/25 flowers†				
	Pollinator row	Adjacent row	Second row	Third row	S. E.
1st (16 July)	408 a*	424 a	354 a	359 a	24.46
2nd (23 July)	481 a	308 b	266 b	267 b	31.08
3rd (30 July)	284 a	232 b	250 ab	223 b	14.13
4th (6 Aug.)	285 a	224 b	269 a	278 a	13.51
4 week total	1,458 a	1,188 b	1,139 b	1,127 b	52.22
Total seeds as % of Pollinator Row	--	81	78	77	79

* Means in the same row followed by the same letter do not differ significantly at the 5% level. † Average of 6 replication.

A significant rank correlation occurred between both weight (rs = 0.795) and number (rs = 0.946) of seeds and nearness to the pollen source. The seed weight to boll weight was significantly less when plants were 6 and 7 rows from the pollen source than rows closer to the pollen plants. Yet all the male sterile rows had a significantly higher percentage of seed weight to total boll weight than the pollen rows. Overall, the male-sterile flowers produced 98% as much seed per flower as flowers on the pollen parent.

In 1974 there were no significant differences in the seed produced in any of the male-sterile rows (Table 2). Flowers in the row adjacent to the pollen plants set better the first two weeks of bloom than plants further away from the pollen plants, and flowers two or three rows removed from the pollen parent set better the 4th week of bloom than flowers in the row adjacent to the pollen plant. The seed weight to boll weight was 68.2% for bolls produced on male sterile flowers and 62.0% for bolls produced on the pollinator flowers. Overall seed production per male-sterile flower was 79% of that of the pollen plant.

Bee visits per cotton flower were high in 1973. The mean visitation rate in July and August was 2.0%, the mean average was 4.9%, and the high was 10.1%. Wild bees were unusually numerous and made up 62% of the hymenopteran visits compared with 38% for honey bees. The most common wild bees visiting cotton in this area were species of *Melissodes, Agapostemon, Halictus, Diadasia, Bombus,* and *Xylocopa* (Moffett et al. 1976a, b)

During the first 4 weeks that bee counts were made in 1974, bee visits ranged from 0.45% to 3.17%, and the average was 1.35%. Honey bees comprised 84% of the bees observed. Wild bees were scarce until after the middle of August, but they became plentiful during the final 3 weeks of observations, which ended in early September. This level of bee visitation was sufficient for adequate hybrid seed production.

A planting pattern of two rows of pollen plants alternating with six rows of male-sterile plants gave satisfactory seed yields when average bee visits per flower at any given time were 0.5% or higher. The 1973 planting pattern of two rows of pollen plants followed by 14 rows of male-sterile plants resulted in reduced seed yields in the male-sterile rows farthest removed from the pollen rows despite a very high wild honey bee population.

Hybrid seed can be produced in commercial quantities when bees are visiting the plants at the rate of 0.5% or higher and male sterile plants are no more than three rows from the pollen plants.

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