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Original article

Does in-hive pollen transfer by honey bees contribute to cross-pollination and seed set in hybrid cotton?

GM Loper, G DeGrandi-Hoffman

US Department of Agriculture, Agricultural Research Service, Carl Hayden Bee Research Center, 2000 East Allen Road, Tucson, AZ 85719, USA

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Summary — Whether or not sufficient amounts of cotton pollen are transferred among nestmates in honey bee hives to influence cross-pollination and seed set in cotton was tested. Honey bees foraged on genetic cytoplasmic male sterile (CMS) cotton flowers in greater numbers than on male fertile (MF) flowers, and most of the foragers on MF flowers collected nectar rather than pollen. Pollen-free worker bees either pinned at the hive entrance or released in the hive obtained very little cotton pollen on their bodies from nestmate contacts, although all of them obtained large amounts of pollen from other plant species. Seed set on CMS plants did not decrease significantly with distance from MF plants in 1988 when foraging activity on CMS plants was high relative to that in 1989. In 1989 when there was less foraging activity on CMS flowers, seed set on CMS plants decreased significantly with distance from the MF row. These studies indicate that there were insufficient numbers of honey bees returning to their colonies with significant amounts of cotton pollen on their bodies to ensure effective transfer of cotton pollen among nestmates in the hive.

foraging behavior /pollen transfer / *Gossypium* / hybrid / pollination

INTRODUCTION

The production of hybrid cotton (*Gossypium* spp) seed requires the movement of pollen from rows of male fertile (MF) flowers to rows of genetic cytoplasmic male sterile (CMS) flowers (Moffett, 1983; Weaver, 1983). In the southwestern US, honey bees *(Apis mellifera)* are rented to provide pollinators for cotton, but some hybrid seed yields have been more than 30% lower than isogenetic male fertile lines in the same field even when honeybee colonies are present (Loper, unpublished observation).

Honey bees transfer pollen between MF and CMS plants by moving between rows during foraging. In many instances,

pollen movement declines with increasing distance from MF plants (Moffett *et al,* 1976; Vaissiere *et al,* 1984; Loper, 1987; DeGrandi-Hoffman and Morales 1989; Mamood *et al,* 1990; Loper and Danka, 1991), because foragers crossing between rows most often move to an adjacent row (Eisikowitch and Loper 1984). Hence, a decrease in pollen on CMS stigmas with increasing distance from MF plants could indicate that movement of pollen-laden foragers from MF to CMS rows might be a limiting factor in the cross-pollination of CMS cotton. Pollen on bees returning to their hives can be redistributed to nestmates in the hive *via* physical contact (*ie,* in-hive pollen transfer as shown by DeGrandi-Hoffman *et al* (1986) in apple pollination). The purpose of our studies was to determine if cotton pollen is transferred in the hive and whether this mechanism might contribute significantly to cross-pollination.

MATERIALS AND METHODS

In 1988 and 1989, 2 honey-bee colonies were located ~5 m from a 0.16 ha plot of cotton. The plot had rows that were 122 m long and ~1 m apart. The planting design in 1988 had 2 rows of MF Pima cotton followed by 2 rows of MF upland, and 8 rows of CMS upland. The same planting scheme was used in 1989, but only 2 rows of MF upland cotton were planted next to 8 rows of CMS upland. In both years there were large acreages of Pima and other MF cotton cultivars (primarily Delta Pine 90) $\leq$ 1 km of our test plots.

Foraging honey bees and CMS and MF cotton flowers were counted twice daily (at 8:00 am and 11:00 am MST) throughout bloom (July 18–August 9 in 1988 and July 10–August 16 in 1989) when weather conditions were suitable for bee flight. Honey bees rarely forage on cotton flowers during summer afternoons in southern Arizona (DeGrandi-Hoffman and Loper, unpublished observation). Honey bees were counted on 2 rows each of MF and CMS plants. All the honey bees in the rows were counted along with the open flowers so that the honey bee counts could be expressed as honey bees per 100 flowers. An analysis of variance (ANOVA) was conducted to determine if differences in the average number of honey bees / 100 flowers occurred between CMS and MF plants within years. If the null hypothesis was rejected, a Tukey's W procedure was conducted (Ott, 1977).

During daily counts of MF flowers, the number of honey bees foraging on MF cotton flowers and collecting pollen were observed. Only those honey bees seen collecting pollen from the anthers and storing it in their corbiculae were counted. All honey bees foraging in both MF rows were counted for each observation, and only those foragers collecting resources from the flowers were included in the counts (*ie,* those honey bees collecting nectar from extrafloral nectaries were not counted). A *t*-test was conducted to determine if there were differences between the percentage of foragers collecting nectar and pollen in each cultivar and year.

In 1988 and 1989 a frame of sealed brood was placed in an incubator set at 34.4°C. Worker bees that emerged were either pinned individually at the hive entrance (pinned bees, 10 live bees per colony) or released (free running bees; 10 bees per colony) in each of the 2 honey-bee colonies located near the cotton plots. The free running bees were marked and their wings were clipped prior to releasing them in the hive. A different color of marking paint was used each day to avoid sampling bees that had been in the colony longer than 6 h. In addition, a subsample of 10 workers from the incubator was examined each day to be certain that they were free of cotton pollen. The honey bees remained pinned or free running for 6 h during the days that bees were foraging on cotton and other plant species. After exposure to nestmates in the hives, the pinned and free running bees were placed individually in glass vials and immediately frozen until they were examined for pollen on their bodies. This procedure was repeated on 11 d in 1988 and 8 d in 1989.

Pollen grains on the bodies of control, pinned, and free-running bees were estimated by rolling each bee on an aluminum scanning electron microscope (SEM) stub treated with adhesive. The stub was sputter-coated with gold for 3 min. Grains of cotton and other species of pollen were counted on the entire stub with an ISI-DSI130 SEM operated at 20 kV (DeGrandi-Hoffman *et al,* 1992). An ANOVA was conduct-

ed to determine if the numbers of pollen grains of cotton and other species differed among the treatments. In addition, a correlation analysis was conducted with data collected from both colonies in 1989 to determine if there was a relationship between the percentage of bees collecting pollen on MF plants and the average number of pollen grains per pinned and free running honey bee (Ott, 1977). The number of seeds per boll was counted from MF and CMS cotton flowers tagged in the experimental plots in 1988 and 1989. Flowers in both MF rows (just the Pima rows in 1988) were tagged as were CMS flowers in rows next to the MFs and in rows 2, 5, and 7 rows away. Ten flowers per row were tagged each day during bloom when bees were foraging on cotton plants. An ANOVA was conducted to determine if seed set differed in CMS rows at various distances from MFs. A Tukey's W procedure was conducted if the null hypothesis was rejected (Ott, 1977).

In 1991, colonies were placed 5 m from a 2.5 ha plot containing 2 rows of MF cotton followed by 4 rows of CMS in a repeating 2 x 4 row planting. This plot was immediately adjacent to much larger fields of commercial Acala-type MF cotton. On July 31, 18 honey bees were caught as they left MF flowers and 2 honey bees were collected from CMS flowers (from 11.30 to 12.30 pm). Additionally, at 12.45 pm, 60 returning foragers were sampled as they approached the entrances of 2 colonies. Ten hive bees were collected from combs containing pollen in each of 2 colonies, and samples of freshly stored pollen from both colonies were examined under a dissecting microscope for the presence of cotton pollen.

RESULTS

In 1988 and 1989, the number of honey bees foraging on CMS and MF cotton was relatively low (table I). Both MF cultivars attracted fewer foragers than did the CMS. Most of the honey bees foraging on MF plants were collecting floral nectar (table II).

In 1988, none of the pinned or free-running bees had cotton pollen on their bodies, even though all of them had pollen of other plant species (table III). In 1989, 16 of the 32 pinned bees had 1–5 cotton pollen grains on their bodies, but only 2 of the 32 free running bees obtained cotton pollen in the hive. All bees had pollen from other plant species on their bodies.

Results from the correlation analysis indicated a significant relationship between the amount of pollen on the bodies of pinned bees and the percentage of bees foraging for pollen MF plants ($F = 11.1$, $r^2 = 69.0$, $P \leq 0.05$) in 1989. However, the correlation between the amount of pollen on the bodies of free running bees and the percentage of foragers on MF plants was not significant ($F = 5.0$, $r^2 = 50.3$, $P > 0.05$).

In 1988 CMS plants set significantly more seed than MF plants regardless of their distance from MF rows (table IV). Seeds per boll on CMS plants next to the MF row were not significantly different from those on CMS plants 5 or 7 rows away. In 1989 CMS plants next to or 2 rows away from MF rows had an average number of seeds per boll that was greater than or

Table I. The average number of honey bees foraging on genetic cytoplasmic male sterile (CMS) and male fertile (MF) cotton flowers in AZ, USA.

Year	*No of observations*	*Cultivar*	*Avg no of honey bees/ 100 flowers* *
1988	62	Pima (MF)	1.52 [b]
	32	Upland (MF)	0.50 [c]
	62	Upland (CMS)	7.30 [a]
1989	62	Upland (MF)	2.0 [b]
	62	Upland (CMS)	4.4 [a]

* Means followed by the same letter within the same year are not significantly different at the 0.05 level, as determined by Tukey's W procedure (critical value = 0.96 for 1988 and 0.99 for 1989).

Table II. Percentage of foraging honey bees collecting pollen or nectar on male fertile (MF) cotton flowers in 1988 and 1989 in AZ, USA.

Year	*Cultivar*	*No of observation periods*[a]	*% of foragers collecting*[b]	
			pollen	*nectar*
1988	Upland	16	17.8 ± 7.9 [b]	82.2 ± 3.7 [c]
	Pima	31	7.1 ± 2.0 [b]	92.9 ± 2.0 [c]
1989	Upland	70	23.4 ± 3.7 [b]	76.6 ± 3.7 [c]

[a] An observation period consisted of observing all honey bees foraging MF flowers in 2 rows and recording the number collecting nectar or pollen; [b] means followed by the same letter within the same cultivar and year are not significantly different at the 0.05 level, as determined by Student's *t*-test.

equivalent to MF plants. CMS plants 5 or 7 rows away from MF's had the lowest numbers of seeds per boll.

The samples of foragers collected from cotton flowers in 1991 showed that they could accumulate large numbers of pollen grains: bees foraging on MF (mean (X) = 2 491, standard error (SE) = 882 pollen grains/bee, N = 2) and CMS flowers (X = 151, SE = 68.3 pollen grains/bee, N = 18). However, only 5 of the 60 bees (8.3%) caught returning to the colonies had cotton pollen on their bodies (X = 56.0, SE = 21.6 pollen grains/bee) even though 17 (28%) bees had other species of pollen on their bodies. No bees had corbicular loads.

Table III. The number of pollen grains and percentage of honey bees with cotton (COT) and other species pollen (OSP) on their bodies when pinned at the entrance (pinned) or released (free running (FR)) in colonies located in cotton fields in AZ, USA.

Year	*No of bees examined*	*Treatment*	*Avg no of pollen grains/bee* *		*% of bees with each pollen type*	
			COT	*OSP*	*COT*	*OSP*
1988	47	pinned	0	39.8 [a]	0	100
	38	FR	0	14.3 [b]	0	100
1989	32	pinned	1.3 [a]	33.9 [b]	50	100
	32	FR	0.3 [a]	17.1 [c]	6.2	100

* Means followed by the same letter within the same year are not significantly different at the 0.05 level, as determined by Tukey's W procedure (critical value = 3.1 in 1988 and 2.9 in 1989).

Table IV. The average number of seeds per boll in male fertile (MF) and genetic cytoplasmic male sterile (CMS) cotton in Arizona, USA. CMS plants were located various distances away from the MF pollen source.

Year	*Cultivar*	*Rows away from MF plants*	*Bolls counted*	*Avg no of seeds/boll* *
1988	Pima–A (MF)	na	259	17.0 [a]
	Pima–B (MF)	na	288	15.6 [a]
	Upland (CMS)	next to	211	25.3 [bc]
	Upland (CMS)	2	211	26.4 [b]
	Upland (CMS)	5	232	23.8 [c]
	Upland (CMS)	7	182	23.6 [c]
1989	Upland–A (MF)	na	233	24.8 [a]
	Upland–B (MF)	na	258	26.5 [ab]
	Upland (CMS)	next to	238	27.7 [b]
	Upland (CMS)	2	280	24.8 [a]
	Upland (CMS)	5	327	20.8 [c]
	Upland (MS)	7	327	20.0 [c]

* Means followed by the same letter within the same year are not significantly different at the 0.05 level, as determined by Tukey's W procedure (critical value = 1.9 for 1988 and 2.5 for 1989).

Honey bees from frames with stored pollen should have the highest probability of having cotton pollen on their bodies due to either recent pollen foraging activity or the storing of collected pollen in cells. In one colony, 8 of the 10 bees had 1–36 cotton pollen grains on their bodies (X = 7.2 grains per bee, SE = 3.7). In the other colony, 4 of the 10 bees had from 1–9 cotton pollen grains (X = 1.9 grains per bee, SE = 1.0). This is in comparison to the average of 2 491 pollen grains on bees exiting MF cotton flowers. Both colonies had small amounts of cotton pollen stored in the cells mixed with a predominance of pollen from other species.

DISCUSSION

These studies indicate that there are insufficient numbers of foragers returning to hives with significant amounts of cotton pollen on their bodies to ensure effective transfer of cotton pollen among nestmates in the hive. Cotton stigmas need approximately 100 viable pollen grains to set a full boll (*ie,* 25–35 seeds per boll) (Waller and Mamood, 1991). It does not appear that foragers can obtain sufficient pollen solely from pollen transfer in the hive to set a boll with a single visit to a flower.

Previous studies to test for the occurrence of pollen transfer in the hive were conducted with species in which honey bees collect much pollen (*ie,* apple (DeGrandi-Hoffman *et al,* 1986) or sunflower (DeGrandi-Hoffman, unpublished observation.)). In cotton, however, most honey bees forage on CMS lines and apparently bring little or no cotton pollen back to the hive. Most of the MF foragers collect only nectar. Although nectar collectors are sometimes covered with cotton pollen,

these foragers often spend 20–30 min meticulously grooming the pollen off their bodies before returning to their hives (Loper, unpublished observation and Waller, unpublished communication). This further reduces the amount of cotton pollen entering the hive.

Although colonies were placed near our cotton plots, we could not be certain that the honey bees foraging on cotton flowers were from our colonies. In 1988 probably few or none of the honey bees that we counted collecting pollen from MF plants were from the colonies we introduced, because we never found cotton pollen on the pinned or free-running bees. However, the relationship between the percentage of honey bees foraging on MF flowers and the average amount of pollen on the bodies of pinned bees in 1989 indicated that some of the bees from the colonies we introduced must have been foraging on the test plots. The weak relationship between the amount of pollen on the bodies of free-running bees and the percentage of bees foraging on MF plants in 1989 may simply be due to behavioral subtleties that confound the bioassay. Pinned bees had the greatest probability of touching a forager with cotton pollen on its body because pinned bees were stationary at the hive entrance and incoming foragers contacted them while entering the hive. Free-running bees had less opportunity to contact foragers because they were young adult workers which, when permitted to roam freely in the hive, most probably moved to the brood combs. Furthermore, if little cotton pollen enters the colony, the amount that might be transferred to any individual bee running free in the hive is probably very small.

The minimal transfer of cotton pollen among nestmates in the hive and the relatively low foraging and pollen collecting activity on MF plants did not always result in reduced seeds per boll on CMS plants with increasing distance from MF plants. It is possible that when foraging activity is high, sufficient movement of bees occurs among all rows so that seed set is nearly homogeneous. However, if foraging activity is low, differences in the probabilities of a bee moving from a MF plant to a CMS may decrease with distance resulting in higher seed set on CMS rows closer to MF rows.

Résumé — Les transferts de pollen par les abeilles à l'intérieur de la ruche peuvent-ils contribuer à la pollinisation croisée et à la mise à graine du cotonnier hybride ? Deux colonies d'abeilles (*Apis mellifera* L) placées le long de champs de coton de 0,16 ha ont été utilisées en 1988 et 1989 pour étudier la pollinisation du cotonnier (*Gossypium* sp). Deux rangées de cotonnier mâle-fertile (MF) cotoyaient 8 rangées de cotonnier mâle-stérile (stérilité mâle cytoplasmique CMS). En 1991 le dispositif de culture comportait 2 rangs de MF pour 4 rangs de CMS. Les abeilles butineuses et les fleurs de cotonnier MF et CMS ont été comptées 2 fois par j, à 8 h et 11 h, durant toute la floraison, quand les conditions météorologiques étaient favorables. Les comptages d'abeilles ont été exprimés en nombre d'abeilles par 100 fleurs. L'étude statistique a été faite par l'analyse de la variance (ANOVA) et par le test de Tukey. En 1988 et 1989, les abeilles émergeant d'un cadre de couvain operculé placé en étuve à 34,4°C ont été soit épinglées individuellement à l'entrée de la ruche, soit relâchées dans chacune des 2 colonies, après clippage des ailes et marquage à la peinture. Les grains de pollen sur le corps des abeilles témoins (non exposées), épinglées ou libres, ont été dénombrés en roulant chaque abeille sur un support en aluminium pour microscope électronique à balayage (MEB), après l'avoir enduit d'une substance adhésive. Les comptages ont

été faits sur l'ensemble du support avec un MEB ISI-DSI130 fonctionnant à 20 kV. Une ANOVA a permis de déterminer si les quantités de pollen de cotonnier et de pollen d'autres espèces différaient d'un traitement à l'autre. Le nombre de graines par capsule a été compté pour les fleurs MF et CMS marquées dans les champs expérimentaux en 1988 et 1989. Ont été marquées les fleurs des 2 rangs MF et les fleurs des rangs CMS adjacents aux rangs MF, ainsi que celles des rangs 2, 5 et 7. Une ANOVA a permis de déterminer si la mise à graine dans les rangs CMS variait en fonction de la distance aux rangs MF. En 1991 des abeilles ont été prélevées entre 11 h 30 et 12 h 30 comme elles quittaient les rangs MF et CMS. Des butineuses qui rentraient ont également été prélevées aux abords de la ruche. On a examiné au microscope s'il y avait du pollen de cotonnier sur des ouvrières prélevées sur les rayons de pollen et dans des échantillons de pollen fraîchement stocké.

En 1988 et 1989, le nombre d'abeilles butinant sur les rangs MF et CMS était relativement faible (0,5 à 7,3 abeilles/fleur) (tableau I) ; les 2 cultivars MF (*G barbadense* et *G hirsutum*) étaient moins attractifs que les CMS. La plupart des abeilles présentes sur les MF récoltaient du nectar (tableau II). En 1988, aucune des abeilles épinglées ou libres n'avait de pollen de cotonnier sur son corps mais toutes avaient du pollen d'autres espèces. En 1989, 16 des 32 abeilles épinglées avaient 1-5 grains de pollen de cotonnier sur leur corps, tandis que 2 des 32 abeilles libres recevaient du pollen de cotonnier dans la ruche ; toutes avaient également du pollen d'autres espèces (tableau III). Le résultat des analyses de régression linéaire indique que la relation n'est significative qu'entre la quantité du pollen sur le corps des abeilles épinglées et le pourcentage d'abeilles butinant sur les plantes MF ($F = 11,1$; $r^2 = 69,0$; $P \leq 0,05$).

En 1988, les plantes CMS ont fourni significativement plus de graines que les MF, quelle que soit leur distance aux rangs MF. En 1989, les plantes CMS adjacentes aux rangs MF, ou 2 rangs plus loin, ont eu un nombre moyen de graines par capsule égal ou supérieur à celui des plantes MF. L'analyse des butineuses prélevées sur les fleurs de cotonnier en 1991 a montré qu'elles pouvaient accumuler de grandes quantités de pollen: 2 492 ± 882, SE pour les butineuses de MF et 151 ± 68,3, SE pour celles de CMS. Néanmoins seulement 5 des 60 abeilles (8,3%) prélevées à leur retour à la ruche avaient du pollen de cotonnier sur leur corps (56,0 ± 21,6, SE), alors que 17 (28%) avaient du pollen d'autres espèces (aucune n'avait de pelote). Les colonies adjacentes aux champs de cotonnier avaient de faibles quantités de pollen de cotonnier stockées dans les cellules, et il était mélangé avec une majorité de pollen provenant d'autres espèces. Cette étude montre que le nombre d'abeilles rentrant à la ruche avec des quantités significatives de pollen de cotonnier sur leur corps est insuffisant pour assurer un transfert effectif de ce pollen parmi les congénères de la colonie.

butinage / transfert pollen / pollinisation / *Gossypium* / hybride

Zusammenfassung — Fördert die Pollenübertragung durch die Bienen im Stock die Kreuzbestäubung und den Samenansatz bei der Hybridbaumwolle? Bei Untersuchungen über die Bestäubung der Baumwolle in den Jahren 1988 und 1989 wurden 2 Bienenvölker (*Apis mellifera* L) am Rande von Baumwollparzellen zu 1,6 ha aufgestellt. In beiden Jahren wurden 2 Reihen von männlich fertiler (MF) Baumwolle *(Gossypium hirsutum)* anschließend an 8 Reihen von zytoplasmatisch genetisch steriler (CMS) Baumwolle

gepflanzt. 1991 wurde ein Muster mit alternativer Pflanzung von 2 MF und 4 CMS Baumwolle benutzt. Sammelnde Honigbienen an MF und CMS Baumwollblüten wurden zweimal täglich während der ganzen Blütezeit gezählt (um 8.00 und 11.00 h), sofern es die Wetterbedingungen zuließen. Die Bienenzählungen wurden als "Bienen pro 100 Blüten" protokolliert. Als statistische Analyse wurden Varianzanalysen und Tukey's W-Verfahren durchgeführt. 1988 und 1989 wurde eine Wabe verdeckelter Brut in einem Brutschrank bei 34,3°C gestellt; die geschlüpften Bienen wurden entweder einzeln am Flugloch genadelt oder nach Markierung durch Farbe oder Flügelkürzen in einem der beiden Völker freigelassen. Die Pollenkörner am Körper von nicht-exponierten Kontrollbienen, und an genadelten und frei laufenden markierten Bienen wurden durch Rollen eines mit einem Klebstoff versehenen Aluminiumstabes von einem Rasterelektronenmikroskop (SEM) über den Körper der Biene gezählt. Die Pollenkörner wurden an dem gesamten Stab mit einem ISI.DSI130 SEM mit einer Betriebsspannung von 200kV gezählt. Es wurde eine ANOVA zur Feststellung durchgeführt, ob die Pollenmenge von Baumwolle und anderen Arten zwischen den unterschiedlichen Behandlungen verschieden waren. Es wurde die Samenzahl pro Fruchtstand von MF und CMS Baumwollblüten bestimmt, die in den Versuchen von 1988 und 1989 markiert worden waren. Es wurden Blüten in beiden MF-Reihen markiert und ebenso Blüten nächst zu den MF's und in den Reihen 2, 5 und 7 Reihen entfernt. Dann wurden eine ANOVA durchgeführt, um zu bestimmen, ob der Samenansatz in den CMS-Reihen in verschiedenen Abständen von den MS's verschieden war. 1991 wurden individuelle Bienen gefangen, als sie gerade MF- oder CMS-Blüten verließen (zwischen 11.30 und 12.30 h). Zusätzlich wurden noch Proben von heimkehrenden Sammlerinnen bei der Annäherung an das Flugloch genommen. Stockbienen von Waben mit Pollen und Proben von frisch gesammeltem Pollen wurden unter dem Mikroskop auf die Anwesenheit von Baumwollpollen untersucht.

Sowohl 1988 wie 1989 war die Zahl der auf CMS und MF sammelnden Bienen relativ gering (0.5 bzw 7,3 Bienen pro Blüte, Tabelle I); beide MF Sorten (*G barbadense* und *G hirsutum*) lockten wenigere Sammelbienen an als die CMS. Die meisten der Bienen auf MF sammelten Nektar (Tabelle II). 1988 hatte keine der genadelten Bienen oder frei laufenden Bienen Baumwollpollen auf ihrem Körper, obwohl alle von ihnen Pollen anderer Arten trugen (Tabelle III). 1989 trugen 16 der 32 genadelten Bienen 1-5 Baumwollpollenkörner an ihrem Körper, während nur 2 der 32 freilaufenden Bienen Baumwollpollen im Stock empfingen. Alle Bienen hatten Pollen von anderen Pflanzenarten an ihrem Körper. Die Resultate aus linearen Regressionsanalysen zeigten eine lineare Beziehung nur zwischen der Pollenmenge am Körper der genadelten Bienen und dem Prozentsatz der auf MF sammelnden Pflanzen ($F = 11$, $r^2 = 69{,}0$, $P \leq 0{,}05$).

1988 war der Samensatz der CMS Pflanzen signifikant größer als bei den MF's, ungeachtet ihrer Entfernung von den MF-Reihen. 1989 hatten die CMS Pflanzen unmittelbar neben oder 2 Reihen entfernt von den MF-Reihen eine mittlere Samenzahl per Fruchtstand, die größer oder gleichgroß war wie bei MF Pflanzen.

Die Proben von Trachtbienen, im Jahre 1991 von Baumwollblüten gesammelt, zeigten ein Potential für große Zahlen von Pollenkörnern auf Bienen, die auf MF sammelten (2492 ± 882, SE) und an CMS Blüten (151 ± 68,3, SE). Jedoch nur 5 von den 60 Bienen (6,3%), die bei Rückkehr zu den Völkern gefangen wurden, hatten Baumwollpollen an ihrem Körper (56,0 ±

21,6, SE), obwohl 17 (28%) andere Pollen an ihrem Körper trugen (keine hatte Körbchenladungen). Bienenvölker in der Nähe von Baumwollfeldern hatten geringe Mengen von Baumwollpollen in den Zellen gelagert, in Überzahl gemischt mit Pollen von anderen Arten. Diese Untersuchungen zeigen, daß eine ungenügende Zahl von Bienen zu ihren Völkern zurückkehrten, die so beträchtliche Mengen von Baumwollpollen an ihrem Körper trugen, um eine effektive Übertragung von Baumwollpollen an ihre Stockgefährtinnen zu gewährleisten.

Sammelverhalten / *Gossypium* / Bestäubung / Pollenübertragung / Hybrid

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