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Cotton Research and Development Corporation.

Final Report - Yield Effects of Cotton Pollinated by Honey Bees.

Mr. John Rhodes, NSW Agriculture, Tamworth, NSW, 2340.

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Cotton Research and Development Corporation.

Final Report

Part 1 - Summary Project Details

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Project Title : Yield effects of cotton pollinated by honey bees.

Part 2 - Project Contact Details

Admin. Contact : Mr. Graham Denney

Organisation : NSW Agriculture

Postal Address : Locked Bag 21 161 Kite Street

Orange NSW 2800

Ph 02 6391 3219 Fax 02 6391 3327 denneyg@agric.nsw.gov.au

Principal Researcher : Mr. John Rhodes

Organisation : NSW Agriculture

Postal Address : RMB 944 Calala Lane

Tamworth NSW 2340

Ph 02 6763 1100 Fax 02 6763 1222 john.rhodes@agric.nsw.gov.au

Supervisor : Mrs. Renata Brookes

Organisation : NSW Agriculture

Postal Address : Locked Bag 21 161 Kite Street

Orange NSW 2340

Ph 02 6391 3210 Fax 02 6391 3327 renata.brookes@agric.nsw.gov.au

Plain English Summary.

A Pilot Study carried out in a NSW cotton crop in 1993 showed that lint and seed production could be improved by up to 25% by honey bee pollination. The current project had the objective of determining whether yield and fibre quality of an irrigated cotton crop grown in NSW could be improved by introducing managed honey bees into the crop.

Field work was carried out during Jan.-Feb., 2000 using a 30 hive commercial apiary situated adjacent to a 47ha cotton crop at Boggabri, NSW. The crop was subjected to standard management practices which included 4 applications of pesticides during the 30 days the apiary was present.

Data was collected from 3 sources - a field trial where bee visit numbers to flowers in 60 plots were recorded and compared to cotton production data from those plots; lint quality was determined from plots receiving high, low and medium numbers of bee visits; and a small cage trial where cotton production was compared between caged rows of cotton with half the cages containing a hive of bees and the remaining cages not containing a hive of bees.

(i) Field Trial. The results for cotton bolls harvested from plots which received the equivalent of 10 bee visits compared to plots which received the equivalent of 0 bee visits were -

significant increases were obtained for the Total Number of Bolls Harvested (11.1%), Total Mass of Bolls (16.5%), Total Lint Mass (15.8%), Total Seed Mass (19.7%), and Total Number of Seeds per Sample (16.5%).

non-significant increases were obtained for the Mass of 100 Seeds (3.8%), Average Single Seed Weight (3.9%), Average Number of Seeds per Boll (4.7%), and Average Weight of Lint per Boll (5.0%).

(ii) Quality examinations showed significant differences with increased bee visits for Micronaire and Fineness, and no significant differences between treatments for the remaining 7 characters examined.

(iii) the Cage Trial resulted in cages with bees showing significant increases for the Total Boll Mass, Total Lint Mass and Total Seed Mass. Non-significant increases were shown for Average Single Seed Weight, Total Number of Seeds, Average Number of Seeds per Boll, Number of Bolls, and Average Weight of Lint per Boll.

These data indicate that the advantage to be gained from including a managed honey bee pollination program in a cotton production program result from an increase in the number of flowers setting bolls which survive to maturity and are able to be harvested. Minor increases in size, weight and quality of individual bolls indicate that these factors have not been reduced at the cost of the increased numbers of bolls harvested.

1. Background.

A Pilot Study on honey bee pollination of cotton carried out in NSW in 1993 resulted in an increase of 25% in the production of lint and seed (Gardner, P and Jones, W, NSW Dept. Agric., pers. com.). Available overseas data indicate that managed honey bee pollination of irrigated cotton crops can increase yield by more than 20%, increase the number of seeds per boll, and improve fibre quality and seed germination.

Where a crop has been identified as being likely to benefit from honey bee pollination then it becomes of interest to the beekeeping industry on the basis that the supply of beehives for pollination by beekeepers may provide financial benefits to both the cotton growers and to the beekeepers supplying the beehives.

This work was carried out to identify benefits from honey bee pollination of an irrigated cotton variety grown in NSW.

2. Objectives.

This project had the objective of determining whether yield and fibre quality of an irrigated cotton crop grown in NSW could be improved by introducing managed honey bees into the crop to increase cross-pollination within the crop.

3. Methodology.

The project was carried out under commercial conditions using an apiary of 30 hives of honey bees placed adjacent to a 47ha cotton crop subjected to standard commercial management and pesticide application practices. The cotton variety used was a standard (non-transgenic) cotton Siokra V-16, the crop was situated 8km east of Boggabri, NSW.

Field data were collected between January 11 and February 11, 2000 when the crop had completed between 10 and 90% of flowering. Hand harvesting of cotton bolls from test plots was carried out over April 28-29, 2000.

Three aspects were considered to provide the required information - a field trial, a cage trial and lint quality.

(i) Field Trial

A field trial was carried out where bee visit numbers to flowers in 60 plots were recorded and compared to cotton production data from those plots.

Honey bee supply - A commercial apiary of 30 double hives of honey bees *Apis mellifera*, was established to provide honey bees for pollination. Cotton rows in the crop had been planted in an approximate north-south direction. Prevailing winds were from the south-east. The apiary was placed 40 metres from the south-west corner of the crop and was sited in this position to minimise damage from pesticides being blown from the crop onto the apiary.

Cotton crop - Three rows of cotton at distances of 45, 140 and 240 metres from the apiary were selected. Twenty plots, each 10 metres long and approximately 60 metres apart, were marked out along each row providing a total of 60 plots. Where there was not sufficient distance in a row to accommodate the 20 plots, then a second row approx. 5 metres east of the main row was also used.

Counts of the number of honey bees visiting flowers in each plot were carried out each hour between 7am and 4pm AEST one day each week over 5 successive weeks. Counts were made by three persons, one per row, walking along the row and recording for each plot -

- (i) the number of honey bees inside a cotton flower (pollinating bees), and
- (ii) the number of honey bees collecting nectar from an extra-floral nectary (number of bees foraging on the crop)

Hand tally counters (Colby Brand) were used to assist with counts. Counts were carried out at walking pace. Honey bees flying through the crop were not recorded.

A separate crop inspection was carried out by one person each week to confirm that sufficient honey bees were not in the crop to warrant a bee count before 7am and after 4pm AEST.

On the day of each bee count, the average number of freshly opened flowers was recorded for a 10 metre plot. This was determined by counting all of the freshly opened flowers in the 20 plots of the middle row.

Pesticide application data for the crop was recorded.

Harvesting the field trial - For each of the 60 plots, a 3 metre strip in the middle area of each plot was hand harvested. Bolls were placed into bags and transported to the Australian Cotton Research Institute (ACRI), Narrabri, NSW, for storage and processing. The number of plants in each 3 metre strip harvested was recorded.

Field trial data - Cotton samples were processed using a small, manually operated cotton gin and the required data were determined by laboratory staff at ACRI.

(ii) Cage Trial.

A small cage trial was established to provide a contrasting set of data. Four caged and 2 open plots of equivalent size, separated from each other by 2 metres, were set up along the 2 rows of cotton closest to the apiary. Each caged plot and the open plots were 2x rows wide and 1.8 metres long.

Cages were 1.8x1.8x1.8 metres in size, cage covering was by a light grade shade cloth with a zippered entrance.

An established nucleus hive of honey bees, 4x full depth frames in size, was placed inside two of the cages. The remaining two cages did not contain bees and excluded outside insects from entering the cages. The 2 open plots were able to be accessed by honey bees from the 30 hive apiary nearby, and by other pollinating insects foraging in the crop.

Newly opened flowers in each of the 6 plots were tagged with cloth ribbon tied around the flower stem each day for 7 days - February 2, 3, 5, 6, 7, 8 and 12. The number of flowers tagged at each date was recorded.

At harvest, April 28, surviving tagged cotton bolls from each plot were hand harvested and delivered to ACRI for processing and examination for the required data.

(iii) Cotton Quality.

Samples of cotton lint were taken from cotton harvested from 6 plots in the Field Trial, on the basis of 2x samples from plots receiving the highest number of bee visits, 2x samples from plots receiving the lowest number of bee visits, and 2x samples from plots receiving a medium number of bee visits. Recognised examinations to determine lint quality were carried out on the samples at ACRI.

4. Results.

Statistical Methods

(i) Experiment A - Field Trial

For Experiment A the cotton yield data was modelled using a linear regression approach. The model fitted was -

$\text{lint (yld)} = a + b \times \text{bvf}$ where bvf is the number of bee visits to flowers, a is an intercept parameter and b represents the slope component.

(ii) Cotton Quality Component

The cotton quality data was modelled as -

$\text{lint} = a + b \times \text{trt}$ where trt is a 3 level factor (High, Medium, Low) of numbers of bee visits to flowers, a is the intercept parameter and b represents the slope.

(iii) Experiment B - Cage Trial

The cotton yield data was modelled as -

$\text{Lint} = a + b \times \text{trt}$ where trt is a 3 level factor (Hive, No Hive, Control) representing the types of cage treatments.

Results Summary

(i) Experiment A - Field Trial

The number of bee visits to a flower, bvf , was a significant factor in the model (slope of line not zero) and positive for Total Number of Bolls, Total Weight of Bolls, Weight of Lint, Total Weight of Seeds, and Total Number of Seeds per Sample.

The number of bee visits to a flower, bvf , was not significant for the variables Lint Fraction, Weight of 100 Seeds, Average Single Seed Weight, Average Weight of Seeds per Boll, and Average Weight of Lint per Boll.

(ii) Cotton Quality

The frequency of bee visits to a flower, bvf , was significant only for Micronaire and Fineness out of the 9 quality characters examined.

When plotted, Row 1 had the highest bvf 's and Row 2 had the lowest. There was not a clear trend along the rows. This may have been caused by inaccuracies inherent in trying to estimate bee visits by spot sampling, looking at similar plots of the yield variables suggests that there are probably field effects as well.

(iii) Experiment B - Cage Trial

The treatment effect, trt, was significant (not all treatments the same) for Total Number of Bolls, Total Weight of Bolls, Total Weight of Lint, Total Weight of Seed, and Total Number of Seeds per Sample

The treatment effect, trt, was not significant for Weight of 100 Seeds, Average Single Seed Weight, Average Weight of Seeds per Boll, Average Weight of Lint per Boll, Number of Flowers Tagged per Plot.

Where there was significance, the mean for Control was highest being approximately twice the mean for Hive which again was approximately twice the mean for the No Hive treatment. The cages greatly lowered the yield, of the two cage treatments the one with the beehive present in it did the better.

Results Detail**(i) Field Trial**

For cotton yield variables, each variable was compared to the number of bee visits to cotton flowers recorded for each plot.

Number of Cotton Bolls Harvested

A linear regression of the total number of bolls harvested against the number of bee visits to flowers gave an equation which had a significant positive slope at the 5% level, Table 1.

Table 1. Predicted values of the total number of bolls harvested.

No. of Bee Visits	Predicted Mean	Standard Error
0	280.77	8.34
5	296.39	4.57
10	312.01	7.86

This implies an increase in the total number of bolls of 5.6% and 11.1% for 5 and 10 bee visits when compared to the 280.8 bolls obtained for 0 bee visits.

Total Mass of Bolls Harvested

A linear regression of the total mass of bolls harvested against the number of bee visits to flowers gave an equation which had a significant positive slope at the 5% level, Table 2.

Table 2. Predicted values of the total mass of bolls harvested.

No. of Bee Visits	Predicted Mean gm	Standard Error
0	1299.34	48.39
5	1406.38	26.54
10	1513.42	45.62

This implies an increase in total mass of 8.2% and 16.5% for 5 and 10 bee visits when compared to 1299.3g for 0 bee visits.

Lint Mass

A linear regression of the total lint mass against the number of bee visits to flowers gave an equation which had a significant positive slope at the 5% level, Table 3.

Table 3. Predicted values of total lint harvested.

No. of Bee Visits	Predicted Mean gm	Standard Error
0	529.29	20.72
5	571.10	11.36
10	612.91	19.53

This implies an increase in lint mass of 7.9% and 15.8% for 5 and 10 bee visits when compared to 529.3g for 0 bee visits.

Lint Fraction

No significant difference was obtained between data for lint fraction for 0, 5 and 10 bee visits to flowers, Table 4.

Table 4. Predicted values for lint fraction.

No. of Bee Visits	Predicted Mean	Standard Error
0	0.410	0.0061
5	0.407	0.0034
10	0.404	0.0058

Total Seed Mass

A linear regression of the total seed mass against the number of bee visits to flowers gave an equation which had a significant positive slope at the 5% level, Table 5.

Table 5. Predicted values of total seed mass.

No. of Bee Visits	Predicted Mean gm	Standard Error
0	672.12	28.50
5	738.43	15.63
10	804.75	26.86

This implies an increase in total seed mass of 9.9% and 19.7% for 5 and 10 bee visits when compared to 672.1g for 0 bee visits.

Mass of 100 Seeds

A linear regression of the total mass of 100 seeds against the number of bee visits to flowers gave an equation which did not have a significant slope, Table 6.

Table 6. Predicted values of total mass of 100 seeds.

No. of Bee Visits	Predicted Mean gm	Standard Error
0	8.64	0.167
5	8.80	0.091
10	8.97	0.157

Average Single Seed Weight

A linear regression of the average single seed weight against the number of bee visits to flowers gave an equation which did not have a significant slope, Table 7.

Table 7. Predicted values of single seed weight.

No. of Bee Visits	Predicted Mean gm	Standard Error
0	0.0864	0.0017
5	0.0881	0.0009
10	0.0898	0.0016

Total Number of Seeds per Sample

A linear regression of the total number of seeds per sample against the number of bee visits to flowers gave an equation which had a significant +ve slope at the 5% level, Table 8.

Table 8. Predicted values of the total number of seeds per sample.

No. of Bee Visits	Predicted Mean	Standard Error
0	7746.60	306.62
5	8385.45	168.15
10	9024.30	289.01

This implies an increase in the total number of seeds per sample of 8.2% and 16.5% for 5 and 10 bee visits when compared to 7746.60 for 0 bee visits.

Number of Seeds per Boll

A linear regression of the average number of seeds per boll against the number of bee visits to flowers gave an equation which did not have a significant slope, Table 9.

Table 9. Predicted values of the average number of seeds per boll.

No. of Bee Visits	Predicted Mean	Standard Error
0	27.58	0.56
5	28.23	0.31
10	28.88	0.53

Weight of Lint per Boll

A linear regression of the average weight of lint per boll against the number of bee visits to flowers gave an equation which did not have a significant slope, Table 10.

Table 10. Predicted values for the average weight of lint per boll.

No. of Bee Visits	Predicted Mean gm	Standard Error
0	1.8751	0.0397
5	1.9223	0.0218
10	1.9695	0.0373

(ii) Quality Measurements

Lint from 6 plots in the Field Trial were examined for quality characteristics. The 6 samples represented 2x highest number of bee visits (High), 2x medium number of bee visits (Medium), and 2x lowest number of bee visits (Low).

Significant differences were found at the 5% level for the quality characteristics of Micronaire and Fineness.

Micronaire (Mic)

Table 11. Effect of honey bee pollination on micronaire measurement of cotton.

Bee Visit Numbers	Predicted Value from Field Data (micrograms per inch)
Low	3.00 a
Medium	3.55 b
High	3.70 b

a is significantly different from b.

The quality determining characteristics of -

Length (Len), Length Uniformity Index (Uni), Strength (Str), Elongation (El), Maturity Ratio (Mat), Short fibre Index (Sfi) and Percentage of Mature Fibres (PM) were measured and examined statistically. No statistical differences could be determined between samples from plots with Low, Medium or High numbers of bee visits for these characteristics.

(iii) Cage Trial

The cage trial involved 6 plots. Two plots were covered with gauze cages and each contained a small hive of bees (Hive), two plots were covered with gauze cages to exclude insects and did not contain a hive of bees (No Hive), the remaining two plots were not caged and were able to be visited by bees from the apiary used in the field trial and by other pollinating insects in the crop (Control).

All references to significance in the following sets of results are at the 5% level.

Total Number of Bolls Harvested

Table 12. Mean total boll numbers for each treatment.

	Predicted No. of Bolls	(\pm se)
Hive	3.86 b	(\pm 0.80)
No Hive	2.77 b	(\pm 0.83)
Control	8.93 a	(\pm 0.80)

a is significantly different from b

Total Mass of Bolls Harvested

Table 13. Mean total boll mass for each treatment.

	Predicted Mass of Bolls (gm)	(\pm se)
Hive	19.44 ac	(\pm 3.147)
No Hive	9.78 b	(\pm .266)
Control	29.51 d	(\pm 3.147)

a is significantly different from b

c is significantly different from d

Lint Mass

Table 14. Mean total lint mass for each treatment.

	Predicted Lint Mass (gm)	(\pm se)
Hive	7.843 a	(\pm 1.467)
No Hive	4.068 a	(\pm 1.522)
Control	14.193 b	(\pm 1.467)

a is significantly different from b.

Total Seed Mass

Table 15. Mean total seed mass for each treatment.

	Predicted Seed Mass (gm)	(± se)
Hive	9.986 ac	(± 1.679)
No Hive	4.854 b	(± 1.743)
Control	16.279 d	(± 1.679)

a is significantly different from b

c is significantly different from d

Total Number of Seeds per Sample

Table 16. Mean total number of seeds per sample.

	Predicted Number of Seeds	(± se)
Hive	117.143 a	(± 23.029)
No Hive	76.077	(± 23.898)
Control	246.286 b	(± 23.029)

a is significantly different from b

Average Single Seed Weight

Table 17. Mean average single seed weight for each treatment.

	Predicted Mean Seed Weight (gm)	(± se)
Hive	0.08607 ac	(± 0.00357)
No Hive	0.06653 b	(± 0.003706)
Control	0.06629 d	(± 0.003571)

a is significantly different from b
c is significantly different from d

Average Number of Seeds per Boll

Table 18. Mean number of seeds per boll for each treatment.

	Predicted Mean No. of Seeds per Boll	(± se)
Hive	30.429 a	(± 1.804)
No Hive	30.154 a	(± 1.872)
Control	27.786 a	(± 1.804)

a means not significantly different.

Weight of Lint per Boll

Table 19. Mean weight of lint per boll for each treatment.

	Predicted Mean Weight of Lint per Boll	Standard Error
Hive	1.976 a	0.133
No Hive	1.558 b	0.138
Control	1.564 b	0.133

a is significantly different from b

Numbers of Flowers Tagged per Plot

Table 20. Mean number of flowers for each treatment.

	Predicted Mean No. of Flowers	Standard Error
Hive	16.143 a	1.475
No Hive	15.846 a	1.530
Control	18.857 a	1.475

a means no significant difference.

(iv) Crop Data**Plant Density and Boll Production**

Table 21. Plant density and the number of harvested bolls from the 3 rows of cotton used in the Field Trial.

Row	Av. Number of Plants/Metre	Av. Number of Bolls Harvested/Plant
1	11.3	9.5
2	12.5	8.2
3	11.8	8.4

(v) Apiary Data**Pesticides**

Pesticide type, and observed effects on honey bee mortality and foraging activity when applied during the flowering period of the cotton crop are shown in Table 22.

Table 22. Pesticide type, application date, crop flowering density, recorded honey bee mortality, and effects on honey bee foraging activity in the crop.

Date 2000	Flower Density (av. no. flowers per 10 metres of row)	Pesticide Application	Bee Mortality (cupfuls of dead bees)*	Foraging Activity of Honey Bees
Jan.				
10		Gemstar 0.5 + Parathion 2.8 lt.	1-2	
11	5.5			low 3.5 times x**
13		Bulldock 0.8 + Comite 2.5 lt.	1	
18		Curacron F 4.0 + Parathion 2.8 lt.	1	
21	23.9			very low 1 times x
25	41.6			low-med 15.1 times x
Feb.				
2	35.2			high 75.1 times x
4		Bulldock 0.8 + Comite 2.5 lt.	nil	
8	52.2			very low 1.2 times x
11	low numbers			no activity

* estimated average number of cupfuls of dead adult bees at the entrance of each hive.

** "x" was the lowest number of bees recorded for a one day count of the total number of honey bees foraging on the 60 plots.

Temperature and Humidity Data

Temperature and humidity data were recorded at the apiary site between January 20 and February 11, 2000 using a Tiny Tag Ultra Data logger positioned in a purpose designed Stevenson Screen. Results are shown in Table 23.

Table 23. Maximum and minimum temperatures and humidities recorded at the project apiary site during the cotton flowering period.

	Max.	Min.
Temp. °C	47.5	10.3
Humidity %	90.5	13.0

Pollen Trap Data

Although bees from the apiary were commonly observed in the cotton crop with their bodies covered with cotton pollen, no cotton pollen was collected in the pollen trap established on one hive to remove pollen from the legs of returning foraging honey bees.

Bees from the apiary were observed flying to and foraging on a sorghum crop 2km from the apiary site. Foraging bees were collecting sorghum pollen until approx. 6.30am AEST for the first 2 weeks the cotton crop was in flower. Sorghum pollen was collected from the pollen trap.

Other plant species flowering within flight range of the test apiary at the same time as the cotton crop were Carpet Weed *Lippia* sp. and Roughed Barked Apple *Angophora floribunda*.

Other Pollinating Insects

Pollen Beetles (Nitidulidae) were present in the crop inside flowers during the full flowering period, and small numbers of Hover Flies (Syrphidae) were present in the crop during the first week of counts only. No other species of pollinating insect was observed in the crop.

5. Discussion.

Current cotton production practices do not encourage management for pollination of the crop within the overall production program.

The Field Trial results show that when the number and mass of bolls harvested from trial plots with the equivalent of 10 bee visits are compared to trial plots which received the equivalent of 0 bee visits -

- (i) significant increases were obtained in the - Total Number of Bolls (11.1%), Total Mass of Bolls (16.5%), Total Lint Mass (15.8%), Total Seed Mass (19.7%), and Total Number of Seeds per Sample (16.5%).
- (ii) non-significant increases were obtained for - Mass of 100 Seeds (3.8%), Average Single Seed Weight (3.9%), Average Number of Seeds per Boll (4.7%), and Average Weight of Lint per Boll (5.0%).

The benefit resulting from honey bee pollination may be measured by the differences in production between plots receiving bee visits from a managed apiary, and production from plots not receiving bee visits, ie. the expected production from a crop which does not have a managed pollination program in place.

When samples of lint from plots receiving high, medium and low numbers of bee visits were examined for quality characteristics, two showed an improvement out of the nine characters measured. These results support the Field Trial results in increased bee visit numbers having a minor beneficial effect on size, weight and quality characteristics of individual bolls.

The Cage Trial resulted in caged plants with a hive showing significant increases over caged plants without bees for Total Boll Mass, Total Lint Mass and Total Seed Mass. No significant improvement was shown between Hive and No Hive treatments for Number of Bolls, Average Single Seed Weight, Total Number of Seeds, Number of Seeds per Boll and Weight of Lint per Boll. These results support the Field Trial data.

Overall, these data indicate that the advantage to be gained from a flowering cotton crop with a managed honey bee pollination program in place is from an increase in the number of flowers setting bolls which survive to maturity and are able to be harvested.

Although not shown by this project, the result may be explained by an increase in "cross pollination" within the crop where "cross pollination" means the transfer of pollen from the flowers of one plant to the flowers of different plants. Honey bee foraging behaviour in the crop would be a major contributor to this occurring. Less pollen transfer between plants, ie. more "self pollination" would be expected in flowers in a crop having fewer numbers of suitable pollinating type insects present.

The results showed minor improvements in the size, weight and quality characteristics of individual bolls. This means that the increase in the number of bolls produced per plant was not at the cost of plants producing smaller bolls or bolls containing lint of a lower quality.

Cotton variety Siokra V-16 has provided this data, other cotton varieties may respond differently to honey bee pollination with different factors being measured showing different levels of benefit.

Data on plant density and boll production, Table 21, is presented to indicate the general condition of the crop used in the project.

Pesticide information and effects on bee activity are shown in Table 22. Of interest, from a bee pollination point of view, is the effect on honey bee activity in the crop resulting from the two opposing factors of -

- (i) the number of freshly opened flowers in the crop and availability of nectar from extra-floral nectaries - attraction to the crop.
- (ii) the effects of the pesticides present on the crop on foraging bees - repellency from the crop.

Four applications of pesticides were applied to the crop during the 30 days the apiary was at the crop. From Table 22, it is seen that significant bee activity on the crop occurred only between January 23 and February 4, ie. 12 days out of 30 days, or 40% of the number of days the crop was in flower.

Since each cotton flower is available for pollination only on the one day that it is open, then these data suggest that improvements in yield recorded from this trial may be improved further by increasing the number of days that honey bees are able to forage on the crop, eg. by reducing the amount of time bees are repelled from foraging on the crop due to the number of pesticide applications and the types of pesticides used.

Honey bee mortality while the apiary was near the crop was measured in cupfuls of freshly dead adult bees present at the entrance of each hive over the 1-3 days following application of the pesticides to the crop. For this project, honey bee mortality was low. The mortality rate of bees did not have a measurable negative effect on their hive's ability to survive and function. The low mortality rate was achieved by careful siting of the apiary in relation to the crop, apiaries sited in less protected areas could be expected to experience heavy bee mortalities resulting from pesticide damage.

Other flowering plant species in the area were considered not to have attracted bees away from the cotton crop in numbers sufficient to affect bee visit numbers on the cotton crop. Carpet Weed was 4km from the apiary and the closest Rough Barked Apple was 2km from the apiary.

6. Impact Assessment.

From a cotton growing aspect, the presence of managed honey bees in the flowering crop has the potential to significantly increase crop yield, with some minor benefits to lint quality.

From a beekeeping aspect the major concerns would be -

- (i) effects of pesticide - bee mortality and possible residues in stored honey, beeswax and pollen
- (ii) transgenic crops - this may not be a concern for honey sold in countries operating under Standard 18A of the Australian New Zealand Food Authority which states that honey derived from bees foraging Genetically Improved crops does not constitute a Genetically Improved food within the meaning of Food Produced Using Gene Technology. Sales of honey collected from Genetically Improved crops may be affected in countries not operating under Standard 18A.
(Crop biotechnology and genetic improvements, the facts, 2000, Aventis Crop Science Pty Ltd, 391-3 Tooronga Rd., East Hawthorn, Victoria.)
- (iii) overall costs/benefits of being involved in cotton pollination - this would be determined from such factors as costs involved in apiary movements and management, surplus honey obtained, and the bee population strength of hives on removal from the crop.

Overall, these results suggest that there would be financial benefits for cotton growers from incorporating managed honey bee pollination into a cotton growing program which utilises minimum pesticide applications during the flowering period, eg. a Predfeast or Envirofeast program.

7. Other Information Developed

Information was collected from the cotton crop on times of day of pollen availability, and times of day of nectar availability from its floral and extra-floral nectaries, and the sugar concentration of that nectar recorded.

This information is to be published in a separate paper.

8. Further Developments

This work was carried out on cotton variety Siokra V-16, similar studies on different varieties would be expected to produce different results.

To progress this work further requires determining data on the foraging behaviour of honey bees on a cotton crop, eg. -

- (i) the minimum number of hives, or foraging bees, in a crop to provide maximum pollination of that crop.
- (ii) the distribution of hives around a cotton crop to provide maximum bee coverage in the crop.
- (iii) management of apiaries around a cotton crop to minimise damage from pesticides.

9. Publications

Data from this project is to be prepared for publication in suitable Cotton Industry and Beekeeping Industry journals.

10. Acknowledgements.

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