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THE SPOTTED BOLL-WORMS OF COTTON (*EARIAS FABIA* STOLL. AND *EARIAS INSULANA* BOISD.) IN SOUTH GUJARAT, BOMBAY PRESIDENCY.

(Final report on investigations financed by the Indian Central Cotton Committee, 1923 to 1931)

BY

B. P. DESHPANDE, M.Ag.,

and

N. T. NADKARNY, B.Ag.



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PREFACE

The investigations on the Spotted Boll-worms described in this Monograph were carried out at Surat from September 1923 till March 1931, by a group of workers appointed by the Bombay Department of Agriculture. Mr. Ramrao S Kasargode was in charge of them during the first five years, after which he had to retire prematurely on account of ill health and consequently they were conducted by me during the remaining four years. My thanks are due to my colleagues, Messrs. S. G. Kadkol, N. T. Nadkarny, B. J. Thakar, M. S. Patel and B. K. Desai for their sincere co-operation. I am greatly indebted to Dr. W. Burns for the guidance and encouragement which I received from him during the period of the last four years of this work. Throughout the period from 1923 to 1931, these investigations were financed by the Indian Central Cotton Committee.

As a result of these investigations, it was found that the 'clean-up' measures, described on p. 91, offered the most promising means of controlling the Spotted Boll-worms. A scheme was, therefore, started in the Broach District in April, 1931, in order to determine the efficiency of these measures and this is still in progress. This scheme also is financed by the Indian Central Cotton Committee.

BROACH,
31st July 1933.

B. P. DESHPANDE.

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THE SPOTTED BOLL-WORMS (*EARIAS FABIA* STOLL. AND *EARIAS INSULANA* BOISD.) IN SOUTH GUJARAT

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(Received for publication on 31st March 1933)

INTRODUCTION

Earias is a widely-distributed genus, occurring all over the world, North and South America [Wardle 1929] Its occurrence as a pest on cotton has particularly been reported from India, Egypt, West Africa, South Africa, Uganda, Portuguese East Africa, South Rhodesia and Fiji.

Boll-worms were known to affect the cotton crop in India prior to 1903, but they came into prominence in 1905 and 1906 [Fletcher and Misra 1921].

During the year 1905, the cotton crop in the Punjab was threatened with a failure due to the attack of some caterpillars and green fly (aphis), [Renouf 1907]. The Director of Agriculture of that Province communicated the facts to the Entomologist to the Government of India, whose observations showed that the failure was largely due to the ravages of the Spotted Boll-worms (especially *Earias insulana* Boisd.). He attributed the unusual abundance of this pest during that season to the rigorous cold of the previous winter, which he thought had destroyed the natural controls, *viz*, the parasites of these worms [Lefroy 1906]. The anxiety about the possible recurrence of this pest in the succeeding season was keenly felt and hence the measures mentioned below, as recommended by him, were advocated.

(1) Cutting and burning of all cotton and *bhendi* (*Hibiscus esculentus*) stalks during the winter.

(2) The use of *bhendi* as a trap crop.

(3) The re-introduction of the parasite, *Rhogas lefroyi*.

The cotton crop in the Punjab during 1906 turned out to be a normal one and therefore Lefroy [1907] inferred that his faith in the re-introduction of the parasites was amply justified.

"From 1906 until 1911, the varieties of cotton grown at Pusa were mostly utilised for the despatch of the parasites to the Punjab, whenever required. It was in the year 1912 that regular sowings of cotton were made and details of observations

started regarding the boll-worms, *E. fabia* and *E. insulana* as well as *Platyedra gossypiella.*" As a result of these investigations, Fletcher and Misra [1921] presented a few of their conclusions in their bulletin on cotton boll-worms. Besides the re-introduction of parasites, the control measure which appealed to them most, was the removal and burning of the cotton plants, which are attacked in their shoots by the boll-worms, before the final thinning of the seedlings is done. A larger seed rate was, recommended to enable this to be done effectively, and without detriment to the interest of the cultivators.

During 1913, Madan Mohan Lal prepared a preliminary report on cotton boll-worms in the Punjab and ascertained that the early summer rains and the parasite *Rhogas lefroyi* effectively checked the prevalence of the worms. If, however, these natural agencies were unfavourable, he suggested the destruction of the early brood of boll-worms in the cotton buds and flowers; and the introduction of the parasite *Rhogas lefroyi*, by parasite boxes.

In the Entomological Meeting at Pusa during 1921, Javeri reported satisfactory results with the use of *bhendi* (*Hibiscus esculentus*) as a trap crop for controlling the boll-worms.

At the next Entomological Meeting at Pusa, Husain and Mathur [1923] presented very useful information about the parasites of the Spotted Boll-worms.

Later on Patel [1924] attributed an enormous loss of early flower-buds and bolls to these worms at Surat, and argued that a tall open habit of the bracts increased the resistance to boll-worms, probably because the parasite (*Microbracon lefroyi* D. and G.) could more easily attack the worms in the flower-buds and bolls of such strains.

This is a short history of the efforts made at intervals by different workers in India for studying this pest and for finding out remedial measures. Ultimately the position with regard to this pest was reviewed by the Indian Central Cotton Committee, Bombay [Burt, 1922] and investigations on the Spotted Boll-worms were started at Surat in September 1923, for ascertaining the loss caused by this pest to the cotton crop in this tract, and for studying control measures. These investigations, which were conducted at Surat from 1923 till 1931, form the subject matter of this publication.

The work was divided into three parts *viz.*, (1) detailed study of life-history and habits of the Spotted Boll-worms, (2) estimation of the damage caused by this pest to the cotton crop, together with the study of the possibilities of improvement in the crop if the pest can be eliminated, and (3) study of control measures.

During the progress of these investigations it was possible to make a few observations on two more pests of cotton, *viz.*, the cotton shoot-roller (*Phycita infusella* Meyr.) and the Pink Boll-worm (*Platyedra gossypiella* Saund.). These observations are included in the Appendices.

Before proceeding further, it is essential to mention that although the Spotted Boll-worms appear on the cotton crop every year in Gujarat, there does not exist any serious complaint against this pest from the cultivators as it is difficult for them to appreciate the damage caused by these insects, due to the peculiar method of feeding of the caterpillars. In the first place, cultivators do not mind the destruction of the cotton shoots, because even otherwise they consider the pruning of the shoots essential for the development of the side branches. Secondly, the larvae feeding in the flower-buds do not attract the attention of an untrained eye, and the shedding of forms caused by these worms passes off as natural shedding which must occur; because they find that out of the large number of flower-buds produced by the cotton plants, only a very few develop into mature bolls, and the remainder drop away as flower-buds or young bolls. In the normal course, therefore, all this imperceptible damage does not alarm the cultivators, and it is often very difficult to convince them of the loss caused by this pest to their cotton crop. It will not be out of place to quote a few remarks made by Lefroy [1906] in this connection while writing about the Bombay locusts.

" The immense swarms and the extraordinary movements of the Bombay locusts give it an enormously exaggerated importance; it fills the imagination and appeals to the human mind. The damage done by the locusts is probably far less than that done yearly by two pests of cotton (*Earias fabia* and *Earias insulana*) or by the moth borer in cane and sorghum (*Chilo simplex*). In point of numbers the locusts are far below the probable numbers of these pests in any one year; in point of destruction and actual loss of crop, the ordinary pests are far ahead of the Bombay locust in its worst years."

SUMMARY

Attention was prominently drawn to the Spotted Boll-worms, for the first time, during the year 1905, due to the failure of the cotton crop in the Punjab. Since then, introduction of parasites, destruction of the damaged plants in the early part of the season and the use of *bhendi* (*Hibiscus esculentus*) as a trap crop, were some of the measures which were advocated for the control of this pest. The position with regard to these worms was reviewed by the Indian Central Cotton Committee during 1922, and at their instance, further investigations on the Spotted boll-worms were started at Surat in 1923. This work continued till 1931 and the present publication embodies the results of these investigations.

The Spotted Boll-worms are active throughout the year, and the period of their life varies between 22 and 35 days. Oviposition takes place only during the night and the moths were observed to lay, on an average, 432 eggs. The larvae invariably go to the soil for pupation in this locality. Both *Earias fabia* and *Earias insulana* are present but it is the former which predominates on cotton, almost throughout the year.

A vigorous growth of the cotton crop commences soon after the close of the monsoon, and the Spotted Boll-worms appear in the cotton fields as soon as the plants are about 9 inches in height. In the beginning, vegetative shoots are destroyed in large numbers, usually during the months of September and October. The larvae turn their attention to the flower-buds as soon as these begin to develop, and the damaged buds drop from the plants. Observations during three years from 1925 to 1928, showed that 34 to 51 per cent of the buds were damaged by these insects out of the total number of buds which dropped from the plants. A part of the larval population diverts its attention to the bolls as soon as they begin to appear. Young bolls drop if they are attacked by these worms, but the older ones continue to stick to the plants, and yield a reduced quantity of damaged *kapas*. During the three years mentioned above, 20 to 69 per cent of the shed bolls were found damaged by these caterpillars.

It was noticed that the rapid multiplication of the pest during the early part of the cotton-growing season was considerably checked, if heavy showers of rain were received during that period. The larval population of *Earias* on cotton was comparatively very high during November and December, and normally it declined rapidly at the end of December or the beginning of January. This decline was partly due to the cold weather and partly due to the activities of parasites.

A method, which has been described as the night-caging method was devised for growing normal cotton plants free from boll-worms for experimental purposes. Trials of growing more than 100 plants by this method, during each of the three seasons, from 1928-29 to 1930-31, showed that the protected plants yielded 81, 54 and 7 per cent more *kapas* than the respective control plants. During the last season the increase was markedly low, because the caged plants suffered heavily from a storm which occurred at the end of October, when these plants had a very much large number of forms on them than the control plants. On the caged plants the bolls opened about 4 to 6 weeks earlier than on the control plants, because the earliest growing forms on these plants were saved from the Spotted Boll-worms.

Measures which were studied for ascertaining the possibilities of controlling this pest consisted of the removal of the attacked shoots; *bhendi* (*Hibiscus esculentus*) as a trap crop; attractants and deterrents for the moths; parasites; soil-mulch; insecticides; and the prevention of the carry-over of this pest from one season to another.

The removal of attacked shoots was not found to be very useful because only a small fraction of the total population of the *Earias* larvae could be destroyed by collecting the shoots which showed the damage prominently.

The use of *bhendi* as a trap crop also appeared to be of questionable utility, because it was found that these insects multiplied more rapidly on *bhendi* than on cotton, and that the disadvantages of encouraging the cultivation of this crop in the midst of cotton seemed to outweigh the advantages.

Cynogas dust and flowers of sulphur were tried as deterrents for the moths, but both of them were found to be injurious to the cotton plants.

Several substances were tried for attracting the *Earias* moths. Cotton-seed cake and sesamum cake, exposed in the cotton fields after mixing with large quantities of water, showed a certain amount of attraction both for the Spotted and Pink Boll-worm moths. The attraction, however, was not sufficiently strong for using these baits as control measures.

All the known important parasites of *Earias* were found to be present at Surat, and there was, therefore, no possibility of importing any of them from outside. A detailed study of the life and habits of the most important parasite, *viz. Microbracon lefroyi* D. and G., showed that it was not practicable to increase its utility by artificial means.

Preliminary trials indicated that the presence of fine soil-mulch in the cotton fields prevented the larvae from going deep into the soil for pupation, and thus exposed them to the heat of the sun and to their predators. It was also observed that if any of the pupae happened to be buried below a layer of an inch or two of pulverised soil, most of the moths emerging from them could not make their way out of the soil. Further critical observations, however, showed that it was impracticable to maintain the required type of soil mulch in the fields, on a large scale, for its successful use as a control measure.

It was ascertained that spraying or dusting the cotton plants with lead arsenate or Paris Green was not useful in controlling this pest. Later on, it was found that calcium arsenate and sodium silico-fluoride were very effective in reducing the population of *Earias* larvae in the cotton fields, because the larvae were killed in large numbers on the dusted plants (especially the tiny ones, which wandered about before commencing to feed after emerging from the eggs). Serious aphis infestation, however, developed on the cotton plants dusted with these insecticides, a few weeks after the use of these poisons, and it proved to be a great obstacle in the way of using these substances for combating the boll-worms. It appeared that the winged aphis were attracted to the plants dusted with these white poisons, and they could multiply there very rapidly because it seemed that the insecticides afforded them immunity from their enemies. Blackening these insecticides, before using, did not serve entirely to get over this trouble. It is considered that insecticides like calcium arsenate and sodium silico-fluoride could be successfully used against these insects if a cheap and efficient method could be discovered for preventing the subsequent trouble, *viz.*, aphis infestation.

The cotton crop in this locality is harvested in the month of March or April, and the next crop is normally sown after the third week of June, according to the condition of the monsoon. The Spotted Boll-worms are active throughout the year and they get their supply of food, between the two cotton-growing seasons, from the fresh shoots sprouting from the standing plants of cotton and their stumps; from the

bhendi plants growing during that period; and from the stray malvaceous weeds, if any of them happen to be in green condition at that time. These observations show that it will be possible to prevent the carry-over of this pest from one season to another, by cutting off its supply of food during the period between the two cotton-growing seasons. This can be achieved if all the cotton plants are uprooted immediately after the harvest of *kapas*; if the cultivation of *bhendi* is prevented during this period; and if stray malvaceous weeds found in green condition during summer are destroyed.

A small implement [Plate XVII, fig. 2 and Plate XX] has been devised by us for uprooting the cotton plants, and trials are now in progress for judging the efficiency of the above mentioned clean-up measures in a selected area of about 480 square miles in Gujarat.

LIFE-HISTORY AND HABITS OF THE SPOTTED BOLL-WORMS

The Spotted Boll-worms which damage the cotton crop in Gujarat consist of two species, *viz.*, *Earias fabia* Stoll., and *Earias insulana* Boisd. Both these are meant when the term Spotted Boll-worms is used in this publication, except where one or the other is specifically mentioned.

Life of the moths

The Spotted Boll-worm moths emerge from their cocoons after sunset till mid-night. Only very rare instances of their emergence after mid-night have been noted, whereas they do not emerge during the day time.

Table I

Time of emergence of the Spotted Boll-worm moths

Time	Number of moths emerged	
	1st case	2nd case
Between 6 P.M. and 8 P.M.	16	8
Between 8 P.M. and 10 P.M.	27	157
Between 10 P.M. and mid-night	5	48
Between mid-night and 6 A.M.	*Nil*	1
Total emergence	48	214

Copulation of the moths takes place in the early hours of the morning. A few of the moths copulate on the night of their emergence, only a few hours after they come out of their cocoons. In most of the cases, however, mating takes place on the 2nd or the 3rd night.

TABLE II

Day of mating after emergence

(Total cases observed =80 pairs)

——	On the night of emergence	On 2nd night	On 3rd night	On 4th night	On 5th night	On 6th night
Number of pairs of moths which mated.	10	38	18	7	4	3

The mating generally extends from 1 to 3 hours. The moths usually separate soon after day-break, but during November and December, a few pairs can often be found resting on the leaves of the cotton plants till 10 A.M.

A good proportion of the moths begins to lay eggs on the first night after their mating, but most of the remaining moths commence oviposition before the fourth night. In a few cases, however, it was noticed that oviposition was delayed for about a week.

TABLE III

Number of moths which commenced oviposition on consecutive nights, after mating

—	1st night	2nd night	3rd night	4th night	5th night	6th night	7th night	8th night	Total moths observed
Number of moths which commenced oviposition.	34	20	10	2	3	1	..	1	71

For various observations the moths were kept in the laboratory in cylindrical glass jars 5 inches in height and 3½ inches in diameter, and the jars were covered with pieces of thin cloth. Moths were fed on sugar solution or diluted honey, which was applied with brushes to the cloth covers.

In captivity, the average life of a moth was found to vary from about 8 to 22 days. A few moths were, however, observed to live for over 30 days, but out of the large number observed, there was only one which lived for 34 days. (App. I, Table I).

Time of oviposition

Casual observations, while handling the rearing cages of moths, gave an impression that the moths laid their eggs during the night-time only. It was surmised that the absence of light may be one of the requirements for oviposition, and therefore a few pairs of moths were kept in perfectly dark chambers during the day time. This, however, did not induce them to lay eggs by day. Definite observations were therefore undertaken to ascertain the exact time of their oviposition.

Moths which had emerged in the laboratory were selected and eleven pairs of female and male moths were arranged. One pair of moths was allotted for each hour of the night, commencing from 8 P.M. The eggs laid by each pair, before and after the allotted hour, were recorded. Thus the first pair was used to note the number of eggs laid by a female moth from 6 P.M. to 8 P.M. and during the rest of the night after 8 P.M. The second pair showed the number of eggs laid before 9 P.M. and after 9 P.M. The other pairs were similarly allotted for each of the remaining hours of the night.

Table IV

Number of eggs laid by each female during the period of 5 days of observation

Pair No.	Total No. of eggs laid	Eggs laid before the allotted hour	Eggs laid after the allotted hour
1	390	230 before 8 P.M. . . .	160 after 8 P.M.
2	253	154 ,, 9 P.M. . . .	99 ,, 9 P.M.
3	351	274 ,, 10 P.M. . . .	77 ,, 10 P.M.
4	383	359 ,, 11 P.M. . . .	24 ,, 11 P.M.
5	397	374 ,, mid-night . . .	23 ,, mid-night
6	406	384 ,, 1 A.M. . . .	22 ,, 1 A.M.
7	392	368 ,, 2 A.M. . . .	24 ,, 2 A.M.
8	320	306 ,, 3 A.M. . . .	14 ,, 3 A.M.
9	268	250 ,, 4 A.M. . . .	18 ,, 4 A.M.
10	398	388 ,, 5 A.M. . . .	10 ,, 5 A.M.
11	434	434 ,, 6 A.M. . . .	*Nil* ,, 6 A.M.

(For details of daily oviposition *vide* App. I, Table II).

These trials showed very clearly the proportion of eggs laid before and after the various hours of the night; that the oviposition was restricted to night-time only; and that 94 per cent of the eggs were laid between 6 P.M. and mid-night and the remaining 6 per cent were spread over the other six hours of the night.

These observations were later useful for devising a method of growing experimental cotton plants free from the Spotted Boll-worms. The details of this method are discussed separately (Page 33).

Egg-laying capacity

In calculating the rate of increase of the Spotted Boll-worms, Lefroy [1906, 2] had assumed 60 as the normal number of eggs laid by a single moth. At Surat, however, it was found that the capacity of oviposition of these moths was considerably higher. Trials during the months of August and September of 1924, showed that a moth could lay as many as 432 eggs on an average (App. I, Table III). It was also noticed that the largest number of eggs is laid during the first few days of oviposition. The above trials showed that 84 per cent of the eggs were laid during the first seven days of the period of egg-laying. The highest number of eggs laid by one moth in a single night was found to be 162, and the maximum number of eggs oviposited by a moth during all its life was 697.

Egg-laying capacity is not constant throughout the year. It declines considerably during the cold months of December and January as can be seen from the following results :—

(1) An average of 341 eggs per moth was recorded from 14 pairs which were under observation in November 1930.

(2) This average went down to 298 eggs per moth in December 1930 when another lot of 14 pairs was under observation.

(3) An average of only 185 eggs per moth was recorded in January 1931 when 8 pairs were kept under observation. (App. I, Table 1).

It was further noted that the food on which the *Earias* larvae are reared has a great influence on the capacity of the moths for oviposition. During September 1929, one set of larvae was fed exclusively on tender shoots of cotton plants; and *bhendi* pods (*Hibiscus esculentus*) alone were offered to the second set of larvae. The moths emerging from both the sets were kept separately and the eggs laid by them were recorded. In the first case (where the larvae were fed on cotton shoots), the moths laid, on an average, 88 eggs, whereas, in the second case (where the larvae were fed on *bhendi*) the moths could lay 399 eggs each. This trial was repeated during February 1930, when 3 sets of larvae were reared exclusively on flower-buds of cotton, bolls and *bhendi* pods respectively; and the moths which developed from them were kept separately for oviposition.

TABLE V

Eggs laid by moths in the above three cases

—	No. of moths observed	Average No. of eggs laid
1. Moths reared from larvae fed on flower-buds . . .	9	196
2. Moths reared from larvae fed on bolls	12	342
3. Moths reared from larvae fed on *bhendi* pods . . .	12	451

WHERE THE EGGS ARE LAID

The eggs are laid singly and cannot be said to be properly fixed to the plants. They are entangled in the hairy parts of the bushes. The moths prefer hairy objects to non-hairy ones for depositing their eggs. When hairy and non-hairy stems of plants are offered to them simultaneously, it is always the hairy ones which have the largest number of eggs on them. In one of the trials *bhendi* pods (*Hibiscus esculentus*) and the fruits of Abutilon (*Abutilon indicum*) were simultaneously placed in the cages of the moths for oviposition. (The fruits of Abutilon are very hairy and give a velvety appearance). The result was that 92·4 per cent of the total eggs were deposited in the hairy surface of the Abutilon capsules and the remaining 7·6 per cent only on the *bhendi* pods.

TABLE VI

Number of eggs laid on the fruits of bhendi *and* Abutilon

1924.

Pair No.	Period of recording observations	No. of eggs on *Abutilon* capsules	No. of eggs on *bhendi* pods
1	27th to 29th August	54	5
2	27th to 31st August	94	1
3	27th August to 6th September	468	33
4	27th August to 3rd September	287	21
5	27th August to 2nd September	241	32
6	27th to 31st August	164	15
	TOTAL .	1,308	107

It was further observed in the laboratory that in the absence of any other material the eggs were thrust in the meshes of the cloth covering of the glass cages; but whenever coarse felt was inserted (for feeding, by soaking pieces with sugar solution) the muslin cloth was abandoned and the eggs were laid deep in the hairy meshes of the felt.

The same tendency has been noticed in the cotton fields, where hairy portions, such as tender shoots, stalks of flower-buds and bolls, and the petioles of leaves are selected for oviposition. The results of the examination of five plants weekly during November and December 1926, and January 1927 for position of eggs on the cotton plant are tabulated below.

TABLE VII

Positions on the cotton plants where the eggs are laid by the Spotted Boll-worms

(20 plants examined in each case)

Positions	November	December	January	Total
Vegetative shoots	41	41	9	91
Internodes of branches	12	13	5	30
Leaf petioles	5	15	6	26
Stalks of flower-buds	11	18	13	42
Stalks of bolls	..	5	10	15
Body of flower-buds and bolls	..	2	1	3
TOTAL ON 20 PLANTS	69	94	44	207

INCUBATION PERIOD OF EGGS

The incubation period of the eggs of the Spotted Boll-worms consists of four days almost throughout the year except during the cold months of December and January, when it occupies about 5 to 7 days.

Just before the tiny caterpillar emerges from the egg, a little movement of a black spot can be observed inside the shell, and within a few minutes the larva comes out by knocking off the micropyle, or sometimes by making an irregular hole on the side. The empty white shell is left behind, and many can be found sticking to the stalks of the flower-buds and bolls on the cotton plants for many days.

LIFE OF THE CATERPILLARS

The term boll-worms is partly a misnomer because the larvae of the Spotted Boll-worms do not restrict themselves to bolls only but feed on the tender vegetative shoots and the flower-buds of cotton plants for a considerable period of the season.

It is an important fact to remember that the tiny larvae, as they emerge from eggs, do not begin to feed directly on the nearest available food. They wander about for a few hours before they select their food and begin to bore into it. The rest of the feeding is done from within, either in tender shoots, flower-buds or bolls. The larva does not stay in any one of these forms during all the period of its life and generally it leaves the form before all the available food in it is exhausted. It feeds for a short period in one part of the plant and then it migrates to another. It is this habit which is responsible for the destruction of many more forms than would actually be required for nourishing the caterpillars. It is very common to find a large number of flower-buds and bolls which have been left by the insects after destroying only small portions of these forms.

The larval period was determined by rearing about a dozen larvae every month. Each caterpillar, as soon as it emerged out of the egg, was kept in a separate glass tube for observation. When these larvae pupated, the pupae were further kept under observation for noting the pupal period.

December, January and a part of February are generally the coldest months in this tract, and during this part of the season the larval life extends to about 14 to 16 days. It diminishes to only 9 days during the month of October. During the remaining part of the year it varies between 10 and 12 days. (Table IX, Page 13.)

The kind of food available for the larvae also has some influence on the length of their life. Observations during October 1924, showed, that larvae which were fed on *bhendi* pods could pupate within 9 days, whereas those which were given only tender vegetative shoots of cotton required 14 days before they could pupate. Similarly, further trials during November and December 1924, showed, that the larvae which were fed on *bhendi* pods pupated after feeding for 11 days in November and 14 days in December, whereas the larvae which were fed only on flower-buds of cotton, required 13 and 15 days respectively during the above two months.

Pupal period

The caterpillars when they are fully fed descend the plant and invariably go to the soil for pupation in this tract. Very rare cases are observed when the larvae pupate on the plants, either in the monsoon when the soil is wet or during the hottest part of the summer when the heat of the surface soil is unbearable.

The larvae generally commence their search for a suitable place for pupation between 9 A.M. and mid-day. They move through the cracks and crevices until they find a suitable place for spinning their silken cocoons. These are generally attached to the clods or are sometimes found in small crevices (Pl. I, Fig. 1). In cases where the pupae are found in finely pulverised surface soil, small particles of soil are attached all over the cocoon.

In normal field conditions the pupae can be traced to a maximum depth of about 10 to 12 inches below the surface of the soil,



FIG. 1. *Earias* pupae in the soil.

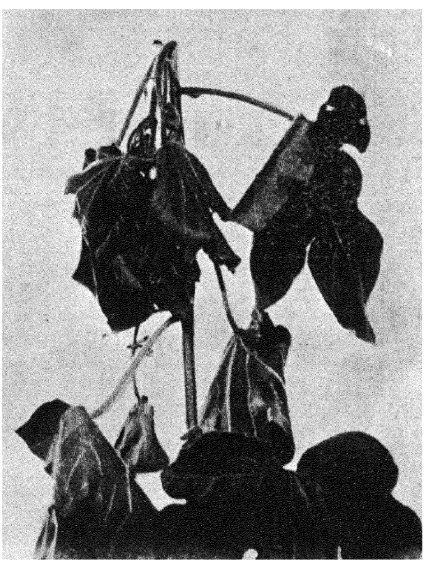


FIG. 2. A cotton shoot damaged by a caterpillar of the spotted boll-worms.

TABLE VIII

Depth at which pupae are found in normal field plots

	Depth in inches												Total
	0-1.	1-2.	2-3.	3-4.	4-5.	5-6.	6-7.	7-8	8-9.	9-10.	10-11.	11-12	
No. of pupae traced during 1928-29.	4	10	5	2	1	1	1	1	.	.	1	.	26
No. of pupae traced during 1929-30.	8	5	9	7	..	..	4	5	..	2	..	1	41

The larvae make their way to these depths through clods and crevices for pupation, and the moths, when they emerge from the pupae, have, therefore, to escape through similar interstices between clods and the loose particles of the soil.

The pupal period varies between 8 and 14 days. The minimum period is observed during April to June and the maximum period during January. (Table IX)

TOTAL PERIOD OF PRE-IMAGINAL LIFE OF THE SPOTTED BOLL-WORMS.

The period of each stage of life of these insects has already been mentioned and the total length of their pre-imaginal life during the different months of the year, from the time the eggs are laid till the emergence of the moths, is summarised in the following table from the information which has already been presented.

TABLE IX

Life of Spotted Boll-worms

Month.	Incubation period in days	Larval period in days	Pupal period in days	Total life in days
December 1923	5	14	13	32
January 1924	5	16	14	35
February 1924	5	11	10	26
April 1924	4	10	10	24
1st fortnight April 1924	4	12	8	24
2nd fortnight May 1924	4	11	8	23
June 1924	4	11	8	23
July 1924	4	10	10	24
August 1924	4	10	9	23
September 1924	4	10	8	22
October 1924	4	9	9	22
November 1924	4	12	12	28
1st fortnight November 1924 . . .	4	11	13	28
2nd fortnight December 1924 . . .	5	14	13	32

It is seen that the shortest period of pre-imaginal life is 22 days in October, the longest period being 35 days during January.

Distribution of the species of spotted boll-worms

Earias insulana Boisd. and *Earias fabia* Stoll. are the two species of Spotted Boll-worms which damage the cotton crop in Gujarat. Both *insulana* and *fabia* are present throughout the year in the cotton fields but it is *fabia* which always predominates. The proportion of *insulana* is generally the highest during the month of November.

Table X

Proportion of Earias fabia *and* Earias insulana *from the larvae colleted from the cotton fields at Surat*

Month	*Earias fabia*	*Earias insulana*	Total	Percentage of *fabia*	Percentage of *insulana*
June 1928	44	28	72	61	39
July 1928	12	2	14	86	14
August 1928	24	4	28	86	14
September 1928	28	4	32	88	12
October 1928	30	14	44	68	32
November 1928	30	30	60	50	50
December 1928	68	30	98	69	31
January 1929	25	8	33	76	24
February 1929	31	7	38	82	18
March 1929	28	4	32	88	12
April 1929	36	13	49	73	27
May 1929	56	18	74	76	24

The predominance of *Earias fabia* can also be seen from the classification of moths which emerged in the laboratory during 1923-24 from the larvae collected from the cotton fields.

Table XI

Period of observation	Total moths emerged	*E. fabia*	*E. insulana*	Percentage *fabia*	Percentage *insulana*
19th November 1923 to 1st January 1924	130	63	67	48	52
17th December 1923 to 30th January 1924	142	72	70	51	49
24th January 1924 to 27th February 1924	67	39	28	58	42
23rd February 1924 to 19th March 1924	155	106	49	68	32
14th March 1924 to 5th May 1924	173	138	35	80	20
10th April 1924 to 15th May 1924	244	184	60	75	25
10th May 1924 to 25th June 1924	390	265	125	68	32

The *bhendi* plants (*Hibiscus esculentus*) are also attacked by the Spotted Boll-worms, but it is *E. fabia* which is mainly responsible for this damage because the proportion of *insulana* found on *bhendi* is very low.

TABLE XII

Larvae collected from Bhendi

Months	*Earias fabia*	*Earias insulana*	Total	Percentage *fabia*	Percentage *insulana*
April 1928	286	8	294	97	3
May 1928	69	8	77	90	10
June 1928	33	1	34	97	3

On *Abutilon* species a good proportion of *insulana* was always noticed.

ARE THE SPOTTED BOLL-WORMS ACTIVE THROUGHOUT THE YEAR ?

There are many insects which remain inactive in one stage of life or another for a part of the year. This period often happens to be the cold season, or it coincides with the period of scarcity of food supply for the particular insect. The study of this factor in the life-history of the Spotted Boll-worms was considered to be an important point and attempts were therefore made to ascertain if these insects had, in this tract, any such period of hibernation or aestivation.

Experience at Surat, while carrying out various trials, showed that these insects could be collected in the fields and could also be bred in the laboratory throughout the year. All the four stages of this pest could be easily found in the cotton fields even during severe winter, or during the summer months. The question had, however, to be examined of the possibility of their aestivating as pupae in the field-soil during summer, after the *kapas* was harvested. Observations were, therefore, undertaken to clear this issue. A large number of full-grown larvae were liberated in small selected areas in a cotton field during the summer months, with a view to find out if these worms would pupate in the soil and remain in aestivation till the commencement of the next season, or would emerge as moths after the normal pupal period. The details of these trials are given below :–

A small area (6 ft. by 6 ft.) was selected in the cotton fields and 1,076 full-grown larvae were liberated in this small space in the last week of March 1928. Before liberating these larvae, zinc sheets were buried around this block of soil to a depth of 3 feet, so that the larvae may not escape from the area under observation through cracks in the soils. The emergence of moths was noted from this area by placing a cloth cage over it.

It was found that 135 moths emerged from this area between the 10th and 15th day, after the larvae were liberated and no emergence was noticed after this period. At the beginning of June, the enclosed soil was excavated and was carefully examined for the cocoons. 497 cocoons were recovered but none of them contained a live pupa.

It is seen that though we liberated 1,076 larvae, we could trace only 497 cocoons after a period of about two months. Out of the remaining 579 larvae, a few must have failed to pupate and the rest must have been completely destroyed after they had pupated in the soil. It is further interesting to note that even out of these 497 cocoons, we could secure only 135 moths, and the remaining pupae were damaged by predators before the moths could emerge.

In addition to this trial, two zinc cylinders, two and a half feet in diameter and open at both ends, were buried in the field soil to a depth of 3 ft., and 200 full-grown larvae were liberated in each of them during the last week of March. The emergence from each of them was recorded by caging the enclosed area. It was found that 75 and 84 moths emerged from the area enclosed by the two cylinders respectively within 11 days after the larvae were liberated. The soil from the first cylinder was examined after 4 weeks and that from the second was examined after 8 weeks from the commencement of the experiment. In both the cases, no live pupa could be traced at the time of soil examination.

Later on, in the last week of May, another group of 200 larvae was liberated in a small space enclosed in a cylinder as mentioned above. Within 10 days, 111 moths emerged from this area and no moth was found after that period. The soil was examined in the last week of June and again no live pupa could be secured.

The observations indicated that there was no possibility of the Spotted Boll-worms aestivating as pupae in the soils, in this tract, during the summer months which intervene between the old and the new crop of cotton.

So far as the cold season is concerned, it was found that it prolonged the life of these worms, and the total period of life extended to about 35 days during the cold weather but no hibernation as such was observed in this locality.

The effect of continuous cold on the pupal period was studied under artificial conditions in one of the experiments. Nine sets of 10 fresh pupae in each case were prepared and they were placed in 9 different compartments of a multiple temperature incubator (Appendix III) where the temperatures ranged from 58° to 125° F.

It will be seen from the next table that the period of pupation was considerably prolonged at lower temperatures, and it covered as many as 24 days in the case of the pupae, which were exposed to a temperature varying between 66° and 70° F. In the adjoining compartment, the temperature varied between 58° and 64° F. and the result was that the pupae from this lot did not hatch out for 30 days. They were removed from there, after this period, and were kept at the room temperature, where the moths emerged normally after four days.

TABLE XIII

Emergence of moths from pupae exposed to varying temperatures

Days after	Number of moths that emerged from different chambers with varying ranges of temperature. (In Fahrenheit.)											
	122 to 125.	110 to 112.	100 to 102.	96 to 98.	90 to 93.	89 to 91.	84 to 86.	80 to 83.	79 to 81.	73 to 75.	66 to 70	58 to 64.
7	All pupae dead and dried up.			..	..	3	..	.	..	..	..	..
8	..	..	..	3	7	1	3	..	..	..	..	..
9	..	..	..	4	2	5	4	4	..	..	..	..
10	..	..	..	..	..	1	2	5	..	..	..	..
11	..	..	..	..	..	..	..	1	3	..	..	..
12	..	..	..	..	..	..	..	.	3	..	..	..
13	..	..	..	..	..	..	..	.	2	1	..	..
14	..	..	..	..	..	..	..	..	..	5	..	..
15	..	..	..	..	..	..	..	.	..	2	..	..
16	.	..	..	..	..	..	..	..	..	1	..	..
17	..	..	..		..	..	.	.	..	..	.	..
18	..	..	..	.	.	..	..	..	..	..	..	..
19	..	..	..	..	..	.	..	.	..	..	..	..
20	..	..	..	..	..	..	..	..	..	..	..	..
21	..	..	..	..	.	..	..	.	..	..	..	..
22	..	..	..	..	..	..	..	..	..	..	2	..
23	..	..	.	.	..	..	..	.	.	..	4	..
24	..	..	..	..	..	..	..	..	..	..	1	..
25	..	..	..	..	..	..	..	..	..	..	.	..
26	..	..	..	..	..	..	..	..	..	..	..	..
27	..	..	..	..	..	..		..	..	..	.	..
TOTAL EMERGENCE	..	..	..	7	9	10	9	10	8	9	10	*Nil* (all live pupae)

The above information will be of considerable interest for tracts like Sind and the Punjab because it indicates the possibilities of the Spotted Boll-worms passing a very long period, in their pupal stage, during the months of severe cold of these provinces.

Moths which emerged in the laboratory during the months of June, July and August were kept in glass jars and were fed regularly on honey in order to find out if the Spotted Boll-worms would be able to pass the period between the two cotton growing seasons in the adult stage.

TABLE XIV

Life of moths kept under observation during June, July and August 1928

Month	No. of moths under observation	Average life in days	Maximum life in days
June	41	8	25
July	89	9·5	22
August	51	8·6	24

It was found that the average life of these moths was not more than 10 days and that the maximum period for which a moth lived did not exceed 25 days in any case.

All the observations, therefore, indicated that the Spotted Boll-worms were active throughout the year in this tract and that no evidence was available of their passing any time of the year in hibernation or aestivation.

FLIGHT RANGE OF MOTHS

Knowledge of the flight range of these moths would be of considerable value for estimating the rate at which fresh infection of this pest would spread. Accurate determination of flight range would probably be possible only in tracts which are free from Spotted Boll-worms. Such a suitable tract was not, however, available for us, and therefore only a few attempts were made to study the question of flight dispersal within narrow limits.

The moths when disturbed during the day time, only flit about a little and settle on plants within a few yards. During the night, however, they travel more extensively.

During one of the weeks of March 1928, 1,875 moths were coloured red and were liberated in the evening in the midst of a big cotton area. Next morning there was no trace of a single moth, near about the spot where they were let out. During the subsequent two or three days, a careful search was made for locating these moths

in the surrounding areas, with a radius of about 500 yards. Only five coloured moths could be secured after this search and the maximum distance at which one of these moths was caught was 300 yards away from the spot where they were originally liberated. It is, therefore, concluded that the moths must have spread out very rapidly beyond the distance of 500 yards where it was not possible to carry on a thorough search.

DAMAGE TO THE COTTON CROP BY THE SPOTTED BOLL-WORMS

Season and plant growth

Before describing the damage caused by the Spotted Boll-worms to the cotton crop, it is desirable to give a brief general account of the environmental conditions of this crop in this tract. (A detailed account of these conditions is given by Maganlal L. Patel [1924] in his memoirs on Gujarat cottons.)

In South Gujarat, the monsoon generally breaks out some time during the latter part of June, and the rainy season continues almost till the end of October. The average rainfall at Surat is 40 inches, and a large part of it is received during the months of July and August. Cotton is sown soon after the first few showers, at the end of June or early in July. The cultivator generally drills his cotton, but dibbling the seed at regular distances is being adopted by some of the cultivators. Desai and Naik [1925] have reported successful results of growing the crop on ridges, which help it to stand the water-logging of the soils during the monsoon at Surat.

In a normal season, cotton seedlings, about four to six inches in height, are seen all over the cotton fields in the month of July, but they do not make any rapid progress in growth for nearly 6 to 8 weeks in the clayey soils of this tract, due to the excessive moisture in the soil and the continuously overcast skies. With the advent of drier and more open conditions, some time during the months of September or October, vigorous growth commences and is followed by rapid formation and development of the flower-buds. Flowers begin to appear in November, and boll development continues during the months of December and January.

The opening of the boll takes place during the months of March and April, and consequently it is during these months that the pickings of *kapas* are made.

Most of the observations at Surat were on plants of the strain called 1027 A. L. F., which is being extensively cultivated in this tract, south of the Nurbuda. The seed was dibbled on small ridges which were prepared before the beginning of the monsoon.

Damage to the vegetative shoots

As soon as the vigorous growth of the cotton crop commences, after the cessation of the monsoon, the Spotted Boll-worms make their appearance in the cotton fields.

They either destroy the tiny buds of the growing shoots or bore into the succulent internodes about 3 or 4 inches below the top of the shoot. When a larva bores into an internode, the portion of the shoot above the bore generally withers and dries up. The appearance of these withered shoots is so characteristic that they can easily be observed from a distance (Pl. I, Fig. 2). In a few cases, however, when the injury is not very severe, the shoot does not dry and the injury caused by the bore is healed up. In the case of the shoots which survive the attack, the scars are visible almost throughout the season. When only the growing vegetative bud is devoured by these worms, the injury is not easily perceptible. Whether the growing bud is destroyed or the shoot is bored into, the ultimate effect, in most cases, is that the further elongation of the branch is stopped and fresh growth is stimulated at the lower nodes.

It must be mentioned here that when the above damage is in progress, the shoot-roller (*Phycita infusella* Meyr.) is also active on the shoots of the cotton plants (Appendix V, Tables II to V). These larvae bind together the top leaves of the branches and feed on the tender leaves from within. The bunch of tied leaves withers and dries up, and consequently in these cases also the further growth of the branches is prevented.

During the year 1925-26, two hundred plants were kept under observation from the beginning of the cotton-growing season for recording the injury caused by the Spotted Boll-worms and the shoot-rollers. Withering of the shoot completely, or merely the destruction of the growing bud, were both reckoned as injury. Ultimately full records for 181 plants were available. It was found that the shoots of the main axis of all these plants were damaged by these insects, 38 per cent of them being destroyed by the Spotted Boll-worms and remainder by the shoot-rollers.

Similar observations were recorded on a group of 200 plants during the year 1926-27 and the progress of attack by the Spotted Boll-worms on the shoots of the main stems can be seen from the next table.

TABLE XV

Week ending	Average height of the plants in cms.	No. of shoots damaged by boll-worms
25th September 1926	19	13
2nd October 1926	23	18
9th October 1926	28	11
16th October 1926	35	48
23rd October 1926	40	18
30th October 1926	44	9
6th November 1926	47	10
13th November 1926	49	1
TOTAL		128

It is seen that the attack on the shoots commenced when the plants were about 19 cms. in height and it continued till the average height of the plants was 49 cms. The maximum number of damaged shoots was in the week ending 16th October, when the average height of the plants was 35 cms.

The boll-worms do not restrict themselves to the shoots of the main stems, but the succulent tops of the side branches are also bored and the growing vegetative buds are destroyed, in several positions on the plants. By the middle of November, however, the internodes of the shoots begin to be woody and are no longer inviting to the worms. The withering of the shoots therefore disappears, but the injury to the growing tips does continue thereafter. A few instances of tiny larvae feeding on the vegetative buds can be traced even during the months of December and January. (Appendix I, Table IX.) An idea of the incidence of the larval population on the vegetative shoots during 6 successive seasons can be obtained from Appendix I, Tables VIII to XIII. It is observed that during most of these years, the boll-worms appeared on the cotton plants some time during the month of September, and a few continued to feed on the shoots at least till the end of November. This continuous mutilation of the growing points, during the period when the main scaffolding of the plant is being built up, results in an irregular growth of the branches, and ultimately the plant appears to be very much more bushy than it would otherwise do.

Damage to flower-buds

With the vigorous growth of the plants, the formation of the flower-buds also commences, and as the developing buds begin to increase in numbers, the Spotted Boll-worms gradually divert their attention from the shoots to the flower-buds. The larvae get into the flower-buds by making a hole and feed on the anthers and ovaries from within. Frequently the buds are abandoned by these larvae after causing only slight injury. It must, however, be remembered that the entrance hole bored by the tiniest larvae invariably causes the shedding of even the biggest bud. Damage by the Spotted Boll-worms is therefore one of the important factors which are responsible for the shedding of flower-buds. Careful observations were maintained on a small number of plants during 3 cotton growing seasons, commencing from 1925-26, for studying this damage to the flower-buds. Weekly counts were maintained from these plants, recording the periodical flower-bud formation, flower opening and the development of mature bolls. The flower-buds and bolls which dropped down from these plants were collected, and were examined for determining the proportion of these forms which showed damage caused by the Spotted Boll-worms. (Appendix I, Tables IV, V and VI.)

The flower-bud formation commenced during the month of September in 1925 and 1927, whereas in 1926, it began early in October. The delay in the commencement of the formation of the flower-buds during 1926 was due to the growth of the plant being retarded by the excessive moisture in the soil caused by heavy rains

(Appendix I, Table VII). It was noticed that in all the three years, shedding of flower-buds due to the Spotted Boll-worms continued throughout the season. The earliest shedding of the flower-buds, however, consisted of a large proportion of tiny buds which generally fail to develop. Within a period of about 6 to 8 weeks after the commencement of flower-bud formation, the proportion of the buds attacked by boll-worms increased, and over 50 per cent of the shed buds indicated damage caused by the *Earias* larvae.

During 1925-26, the flower-buds suffered heavily from this damage, almost from the beginning of October till the end of November. In 1927-28, similar damage was observed from the beginning of November till the middle of December. The year 1926-27 turned out to be the worst boll-worm year, and a considerable amount of damage to the flower-buds occurred during that year from the middle of November 1926 to the middle of January 1927.

TABLE XVI

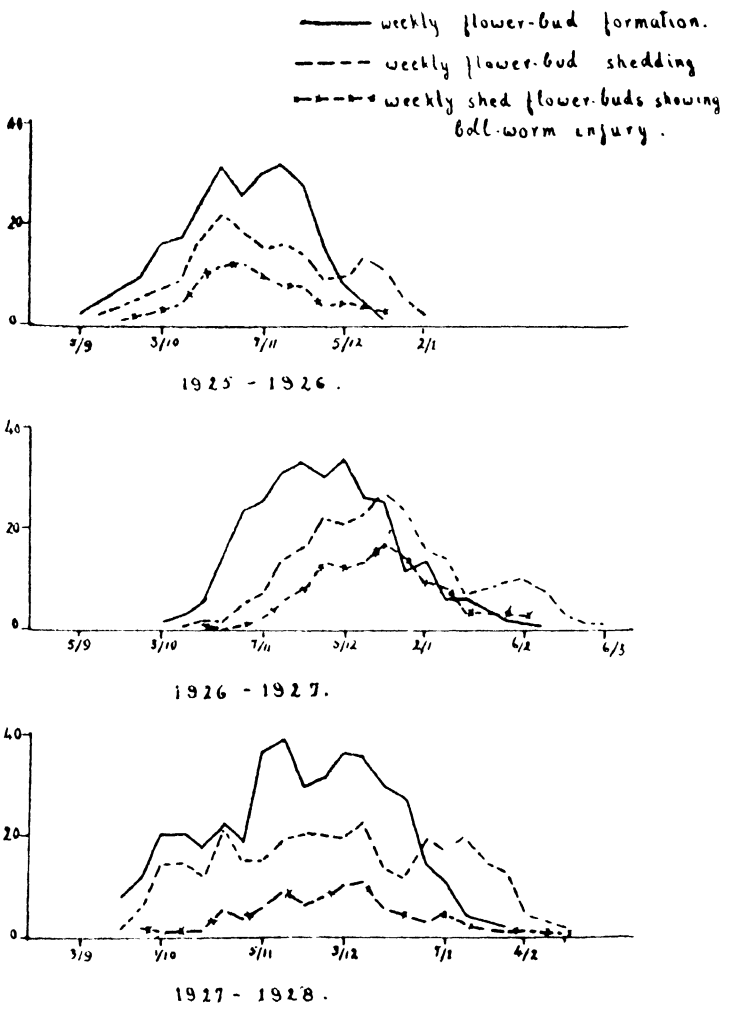
Proportion of the flower-buds damaged by the Spotted Boll-worms

Year	No. of plants observed	Total No of flower-buds formed per plant	Total No of flowers opened per plant	Percentage of flowers opened to buds formed	Total buds shed per plant	Shed buds examined per plant	Shed buds damaged by boll-worms per plant	Percentage of shed buds due to boll-worms to the total shed
1	2	3	4	5	6	7	8	9
1925-26 . . .	49	252	74	29	179	163	79	48
1926-27 . . .	20	297	59	20	238	222	114	51
1927-28 . . .	16	411	96	23	314	244	82	34

Out of the total flower-buds formed, from 20 to 29 per cent opened into flowers and the remainng 71 to 80 per cent shed as buds during the three seasons under consideration. It was further noted that out of this large proportion of flower-buds which dropped away from the plants 34 to 51 per cent (roughly one-third to one half) were injured by the boll-worms (Plate II).

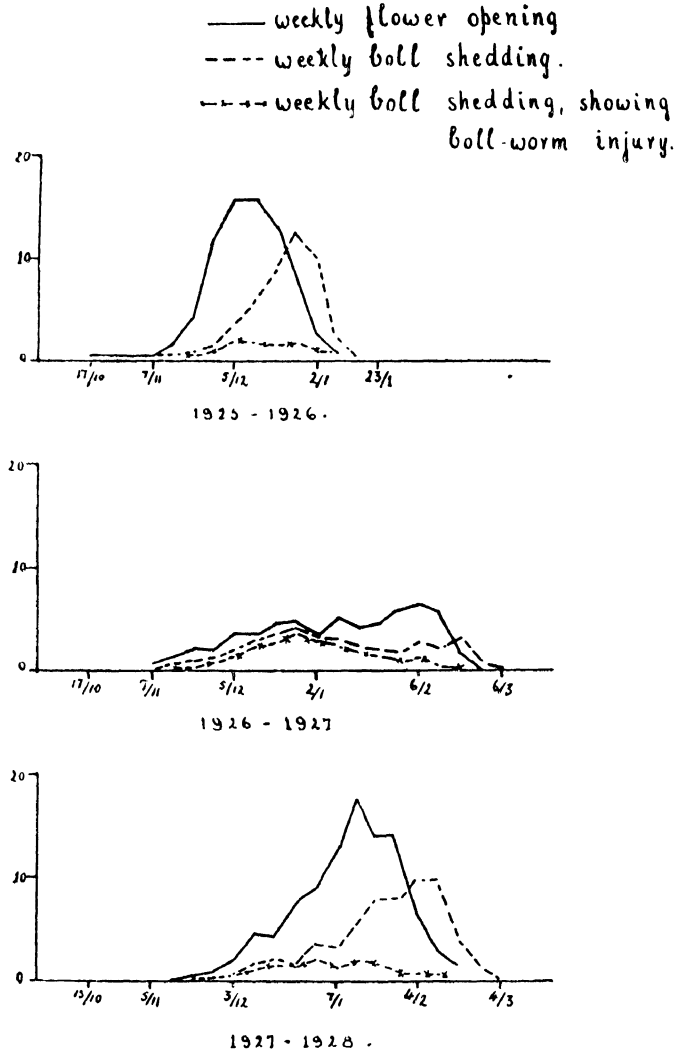
DAMAGE TO FLOWERS AND BOLLS

The shedding of flower-buds due to the boll-worms delayed the period of flower-formation. In fact, intense flower opening was observed during the above three



Showing periodical flower-bud formation, total bud-shedding, and the bud-shedding due to boll-worms from cotton plants at Surat, during three seasons

PLATE III.



Showing periodical flower opening, boll-shedding and the boll-shedding due to boll-worms from cotton plants at Surat, during three seasons

seasons only after the decline of the shedding of flower-buds due to these insects, (Appendix I, Tables IV, V and VI). This fact was particularly brought out during the year 1926-27 when not only the flower opening commenced very late, but it continued to be very tardy, and a slight intensity of flowering could only be noticed as late as after the end of January.

The Spotted Boll-worms begin to concentrate on the flowers and young bolls as soon as the flower opening begins. When a flower is attacked, the larva, in most cases, enters the ovary and destroys it. Consequently the flower withers and sheds within 3 to 5 days The developing bolls also are attacked at all stages of their growth. Young bolls, before they are about half grown, drop away from the plants when they are damaged by the Spotted Boll-worms, but the bigger bolls continue to stick to the plant, even when they are injured. These bolls naturally yield damaged *kapas*.

It has already been mentioned that the flower-opening is delayed due to the shedding of flower-buds attacked by these larvae. It is further observed that the intensity of attack on the flowers and young bolls at the commencement of the flower-opening delays the boll formation and ultimately the opening of bolls.

It will be interesting to scrutinise the details of the damage to the flowers and young bolls. During 1925-26 the flowering commenced in the week ending on 17th October, and during the first four weeks of the flowering, 76 flowers opened on the 25 plants under observation. Out of these flowers, only 14 bolls developed, and the remaining 62 flowers dropped away, of which 54 (*i.e.*, 87 per cent) were injured by boll-worms. Thereafter, the intensity of the damage of these insects declined and the major crop of bolls was obtained from flowers which opened from the middle of November to the middle of December.

Similarly during 1927-28, fifty-six per cent of the flowers which opened in the first six weeks of the flowering dropped away, and 67 per cent of the sheds were damaged by the boll-worms. The major part of the crop of bolls during that season was gathered from flowers which opened from the middle of December till the 3rd week of January.

The performance of the plants during 1926-27 was, however, particularly interesting. During that year the flower opening commenced at the end of October, but 70 per cent of the flowers which opened till the end of December were destroyed by the boll-worms, and 79 per cent of the final crop was built up from the last flowers which opened after the beginning of January. It was also noticed that due to this continuous destruction of the flowers and young bolls, the flowering was very protracted and continued from the end of October till the end of February (Plate III).

These observations have, therefore, shown very clearly that the success of bolls from the earliest flowers is considerably reduced, due to the shedding of bolls caused by the Spotted Boll-worms, and that the flowering period is prolonged if the severity of attack on the flowers and young bolls continues for a long period.

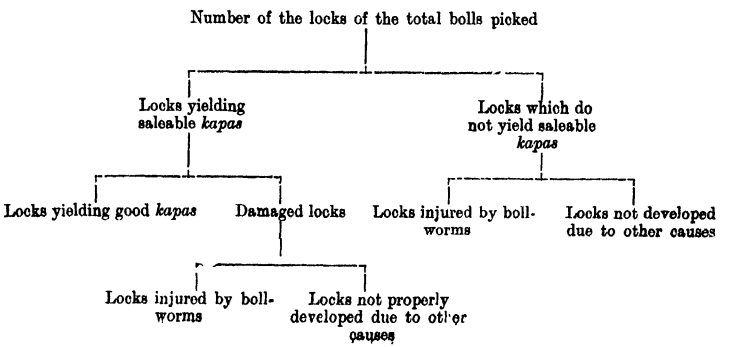
TABLE XVII

Year	Plants observed	Total flowers opened per plant	Bolls shed per plant	Bolls shed due to boll-worms per plant	Percentage of the bolls shed due to boll-worms out of the total shed	Percentage of bolls shed due to boll-worms to the flowers opened
1925-26 . .	49	74	46	10	22	13·5
1926-27 . .	20	59	35	24	69	41
1927-28 . .	16	96	59	12	20	12·5

Out of the 3 seasons under consideration it was during 1926-27 that the largest proportion of the shed bolls showed injury caused by the Spotted Boll-worms, and that 41 per cent of the total flowers were destroyed by the boll-worms in that season. During the other two years this damage was restricted to only 13·5 per cent and 12·5 per cent of the total flowers.

It has already been mentioned that some of the developed bolls are also attacked by these worms and that such bolls yield damaged *kapas*. All the dirty *kapas* that we find at the time of pickings, however, is not due to the injury of the Spotted Boll-worms alone, because the Pink Boll-worm (*Platyedra gossypiella* Saund.) is responsible for a greater part of this damage to the developed bolls. The Pink Boll-worm appears in the fields just when the bolls are developing and rapidly increases in numbers. (Appendix VI, Tables VII to XII.)

For ascertaining the total damage to the bolls caused by both the pests, more than 100 plants were kept under observation during 1928-29, 1929-30 and 1930-31 and all the bolls from these plants were carefully picked and the damaged and the sound locks of these bolls were separated out into different classes as mentioned below :—



The results of this classification of the locks during the years mentioned above are summarised in the next table.

TABLE XVIII

(Average per plant)

Year	No. of plants observed	Total locks picked	Locks yielding saleable *kapas*			Useless locks with unsaleable *kapas*	
			Sound locks	Damaged locks		Damaged by boll-worms	Not developed due to other causes
				Due to boll-worms	Due to other causes		
1928-29 . .	104	202·4	144·2	38·3	8·8	6·9	4·2
1929-30 . .	112	170·6	156·2	9·0	2·3	2·5	0·6
1930-31 . .	116	211 8	190·6	17·7	1·3	2·1	0·1

The sound and the damaged locks of the saleable *kapas* were collected and weighed separately, and an idea of the extent of the damaged *kapas* can be had from the next statement.

TABLE XIX

(Average per plant) Plants spaced 4′ by 4′

Year	No. of plants observed	Total saleable *kapas* in Grms.	*Kapas* from sound locks in Grms.	*Kapas* from damaged locks in Grms.	Percentage damaged *kapas*
1928-29	104	130·6	105·5	25·1	19
1929-30	112	113·2	107·9	5·3	4·7
1930-31	116	150·1	140·7	9·4	6·3

It is seen that the proportion of the damaged *kapas* was very high during 1928-29. It appears that this was mainly due to a severe attack of the Pink Boll-worm during that season. (Table XI of Appendix VI.)

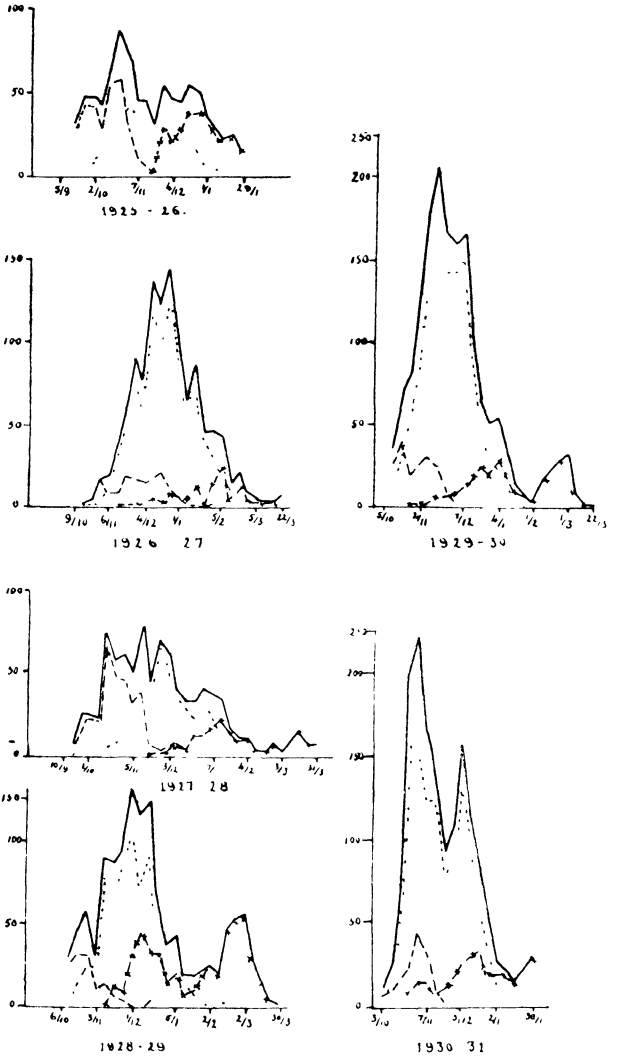
It is very difficult for a casual observer to appreciate the damage caused by the Spotted Boll-worms to the cotton crop as the plant apparently looks quite healthy, and caterpillars feeding on the crop hardly attract the attention of an untrained eye. The observations described above will, however, show the continuous damage to which the cotton crop is subjected by this pest from the beginning to the end of the season.

ABUNDANCE OF THE SPOTTED BOLL-WORMS IN THE COTTON FIELDS AT SURAT

An idea of the comparative abundance of a pest can be obtained if we can estimate its population periodically in a given area of the crop, which is damaged by that pest. In order, therefore, to study the increase or decrease of the Spotted Boll-worms in the cotton fields at Surat, the larval population, on a fixed number of plants, was ascertained weekly. Five small plots of cotton were reserved for obtaining plants for examination, and from these plots 5 plants were collected daily by cutting one plant from each plot. A total number of 25 plants was examined every week, except during the commencement of the growing season when a large number of seedlings had to be examined to trace out the population which naturally used to be very meagre at that time. For these observations all the parts of these plants were separated out in the laboratory and all the shoots, flower-buds and bolls were carefully examined to record the larvae which might be feeding in them. The number of empty forms, from which the larvae had escaped after feeding was also noted. Incidentally notes were also maintained about the presence of shoot rollers (*Phycita infusella* Meyr.) and the Pink Boll-worm (*Platyedra gossypiella* Saund.). The information about these pests is separately presented (Appendices V and VI).

These observations for the larval population of the Spotted Boll-worms were carried out during 6 successive seasons from 1925 to 1931 and the results are tabulated in 6 separate statements in Appendix I, Tables VIII to XIII.

These statements show that the Spotted Boll-worms make their earliest appearance on the shoots of the cotton plants. They divert their attention to the flower-buds as these begin to appear, and for a few weeks the attack continues, both on shoots and flower-buds. When the boll development begins, a part of the population shifts from flower-buds to bolls (Plate IV). It is interesting to note that when both flower-buds and bolls are present there is proportionately a larger number of Spotted Boll-worms feeding on bolls than on flower-buds. This indicates that they prefer bolls to flower-buds. It must, however, be remembered that they feed on the flower-buds for the longest period in the cotton-growing season.



Showing the distribution of the population of *Earias* larvae on different parts of 25 plants during 6 consecutive seasons at Surat.

TABLE XX

Spotted Boll-worm larvae found in every 100 flower-buds and every 100 green bolls present on 25 plants at the time of weekly examinations

1929-30

Date	No. of buds	No. of larvae in flower-buds	No. of larvae for every 100 flower-buds	No. of green bolls	Total larvae in bolls	No. of larvae for every 100 bolls
23rd October 1929 . .	1,137	58	5·1	6	3	50·0
30th October 1929 . .	1,667	86	5·2	8	2	25·0
8th November 1929 . .	1,993	143	7 2	5	2	40 0
14th November 1929 . .	2,627	167	6·4	17	6	35·3
21st November 1929 . .	2,529	143	5·7	20	7	35·0
28th November 1929 . .	3,381	143	4·2	32	7	21·9
5th December 1929 . .	3,637	153	4·2	72	11	15·3
12th December 1929 . .	3,829	92	2·4	149	15	10·0
19th December 1929 . .	2,673	45	1 6	338	24	7·1
26th December 1929 . .	2,831	30	1·1	493	21	4·2
2nd January 1930 . .	2,537	24	0 9	866	29	3 3
9th January 1930 . .	1,721	15	0·8	1,350	23	1·7
16th January 1930 . .	940	3	0·3	1,814	11	0·6
23rd January 1930 . .	288	2	0·7	1,468	7	0·5
30th January 1930 . .	67	..	..	1,102	3	0·3

TABLE XXI

Spotted Boll-worm larvae found in every 100 flower-buds and every 100 green bolls present on 25 cotton plants at the time of weekly examinations at Surat

1930-31

Date	No. of flower-buds	No. of larvae in flower-buds	No. of larvae for every 100 flower-buds	No. of green bolls	Total larvae in bolls	No. of larvae for every 100 green bolls
24th October 1930 . .	2,260	158	7	50	9	18·0
31st October 1930 . .	1,977	155	7·8	43	14	32·6
7th November 1930 . .	1,777	122	6·9	51	12	23·5
14th November 1930 . .	2,107	123	5·8	33	6	18·2
21st November 1930 . .	2,688	78	2·9	32	9	28·1
28th November 1930 . .	3,998	90	2·2	75	15	20·0
5th December 1930 . .	5,192	132	2·5	208	24	11·5
12th December 1930 . .	4,224	91	2·1	288	28	9·7
19th December 1930 . .	4,207	52	1·2	868	33	3·8
26th December 1930 . .	3,917	33	0·8	1,707	19	1·1
2nd January 1931 . .	2,198	13	0·6	1,895	17	0·9
9th January 1931 . .	927	6	0·6	2,167	17	0·8
16th January 1931 . .	225	1	0·4	1,692	13	0·7
23rd January 1931 . .	18	..	..	1,248	20	1·6

A compact statement of the weekly larval population on 25 cotton plants during the above mentioned 6 years is given in Table XXII.

TABLE XXII

Weekly population of the Spotted Boll-worms on 25 cotton plants at Surat

(Plants spaced 3′×3′ during 1925-26, 1926-27 and 1927-28 and 4′×3′ during 1928-29, 1929-30 and 1930-31.)

Week ending	1925-26	1926-27	1927-28	1928-29	1929-30	1930-31
5th September . . .	..	..	..	..	..	1
12th September . . .	..	..	..	2	..	1
19th September . . .	32	..	8	..	1	2
26th September . . .	48	..	25	1	1	18
3rd October . . .	48	..	24	4	7	13
10th October . . .	43	..	22	29	35	28
17th October . . .	68	3	74	45	70	78
24th October . . .	87	5	57	56	81	196
31st October . . .	73	16	61	32	114	220
7th November . . .	45	19	51	89	176	167
14th November . . .	45	38	78	86	204	145
21st November . . .	32	62	46	95	167	90
28th November . . .	54	91	69	130	159	108
5th December . . .	47	76	63	115	165	157
12th December . . .	44	138	42	123	107	122
19th December . . .	55	123	34	65	69	85
26th December . . .	51	144	34	37	51	53
2nd January . . .	38	*	41	40	54	30
9th January . . .	30	67	38	19	38	23
16th January . . .	22	86	35	18	14	14
23rd January . . .	25	47	18	20	9	20
30th January . . .	14	47	12	25	3	28
6th February . . .	..	44	11	19	18	37
13th February . . .	..	15	4	46	25	23
20th February . . .	..	21	2	54	28	17
27th February . . .	..	9	6	56	..	4

*Not examined.

The time of the earliest rise of the population of these larvae in the cotton fields has varied considerably during these 6 years. In 1925-26 this rise was found to be the earliest, while during the next season it was abnormally delayed till the middle of November. In 1927-28 again the boll-worms began to increase in numbers before the end of September, whereas the commencement of similar rise was noticed by about the second week of October during the remaining 3 seasons.

The intensity and distribution of rainfall were important factors in determining the time of the rapid increase of the Spotted Boll-worms, because rain had a depressing effect on their multiplication, and therefore the rise of the population could not begin so long as the rains continued (Plate V). It was also noticed that the population rapidly declined if heavy showers of rain were received even during the later part of the cotton growing season.

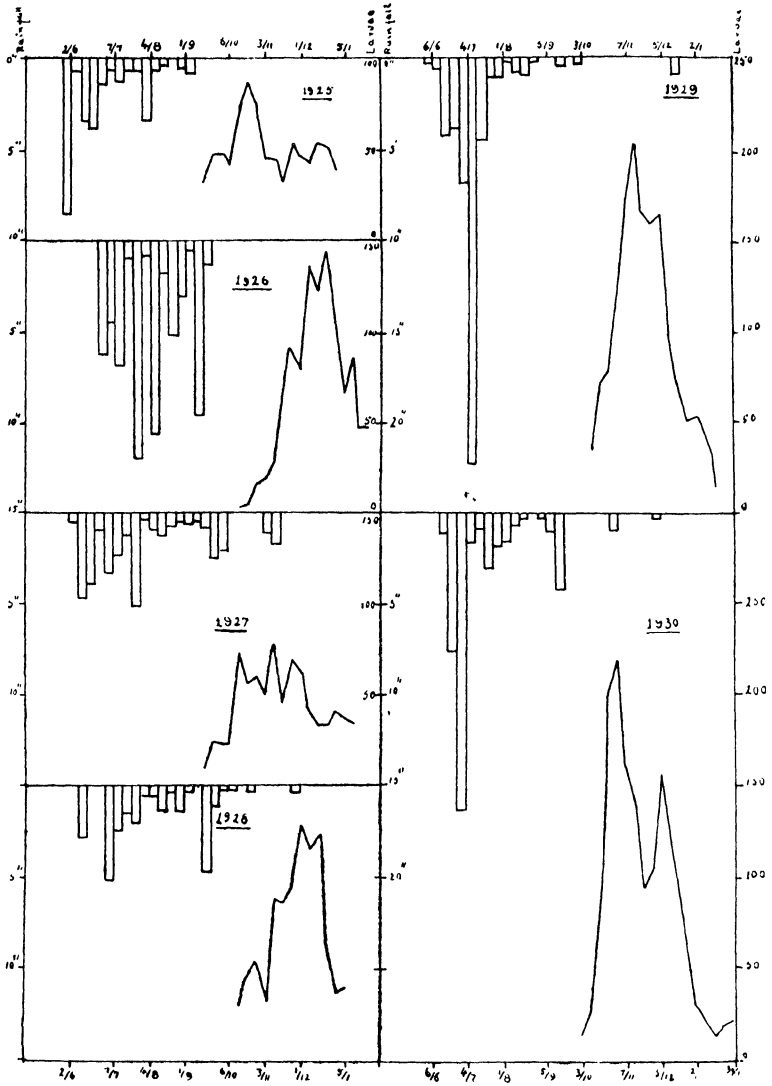
Thus on 12th and 13th of November 1927, the rainfall was 2·88 inches. This was followed by a sudden drop in the larval population on the 25 plants from 75 to 44 during the next week. Similarly the population rapidly declined after a storm which occurred on the 29th of October 1930, and which was accompanied by 0·90 inches of rain.

TABLE XXIII

Rainfall at Surat from 1925 to 1930

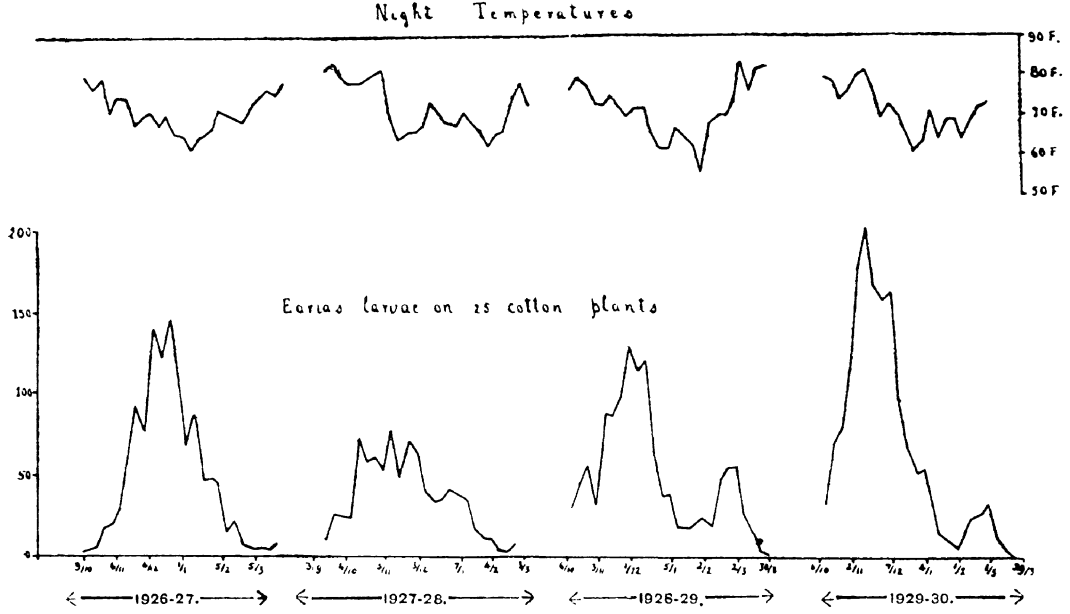
(In inches)

Month	Fortnight	1925	1926	1927	1928	1929	1930
June	First	10·78	..	0 45	2 91	0·78	0·11
	Second	6 55	0 97	9 51	..	8·26	16·32
July	First	1·41	15·68	5·93	8·59	33·78	10·41
	Second	1 45	13 28	6·41	3·27	0·54	5·54
August	First	3·82	11 68	1·50	2 11	1 80	2·19
	Second	0 33	8 09	1·99	1 85	1·45	0 26
September	First	1 04	6·65	0 99	0 38	..	5·34
	Second	..	6 60	3·25	5·90	0·45	0·06
October	First	..	..	2·15	0·49	0·32	..
	Second	..	..	..	0·38	..	0·95
November	First	0·06	..	2·88	..	..	..
	Second	..	..	..	0·29	..	..
	TOTAL	25 44	62·95	35 08	26·17	47·38	41·18



Showing incidence of larval-population of *Earias* larvae on 25 cotton plants and weekly rainfall during six consecutive seasons at Surat.

PLATE VI



Showing the mean night temperatures and the periodical population of *Earias* larvae during four consecutive seasons at Surat

The year 1925 had a very peculiar type of monsoon. During that year Surat had, from June to November, a total of 25·44 inches of rain, of which 17·33 inches were received in the month of June. The remaining 8 inches were spread over the next 3 months. The Spotted Boll-worms, therefore, got the earliest opportunity of increasing in numbers during that season.

The next season had the heaviest rainfall, and all the 3 months of July, August and September continued to be very wet. The result was that the rapid multiplication of this pest during that year was delayed till the middle of November.

The year 1927 was not quite as dry as 1925 but there were no heavy rains during August and September, and therefore a good beginning of boll-worm population was noticed in the last week of September.

The boll-worms would have increased in numbers before the end of September in 1928, because the period from the beginning of August till the middle of September was not very wet. The heavy showers received during the 2nd fortnight of September, however, delayed their rise till the 2nd week of October.

During the next two seasons the heavy rains in June and July followed by small showers during the next few weeks kept off the serious rise of the pest till the middle of October.

The various indications mentioned above, have, therefore, shown that a heavy rainfall is always effective in checking the rapid increase of the Spotted Boll-worms.

These observations have further shown that the population of the Spotted Boll-worms declines rapidly every year at the end of December or some time in January. Scarcity of food does not seem to be a reason for this, because a large number of flower-buds and bolls can still be found on the cotton plants, when the population of these insects begins to fall. It appears that this decline is partly due to the activities of the parasites of these worms and partly to the effect of climatic conditions.

The following 3 parasites are generally active during the months of November and December, and are responsible to a great extent in controlling the Spotted Boll-worms.

(1) *Microbracon lefroyi* D. and G.
(2) *Actia aegyptia* Vill.
(3) *Rhogas testaceous* Grav.

The cold season generally begins just about the time when the population of the Spotted Boll-worms declines. The cold season prolongs the total life of these worms, and consequently their rate of multiplication is decreased. It is further observed that the period of the decline of these insects and the fall in the night temperature generally coincide (Plate VI). It has been remarked earlier that the capacity of oviposition of the moths declines appreciably with the commencement of the cold weather (Page 9).

In short the Spotted Boll-worms begin to increase rapidly in the cotton fields soon after the close of the monsoon. They feed on the shoots, flower-buds and bolls as they begin to appear in succession. The cotton plant at Surat shows a very great

capacity of getting over all this damage. When the growing shoots are destroyed, fresh growth commences at other points; when the developing flower-buds are damaged, the younger ones begin to develop and open into flowers; and when young bolls drop down due to the injury caused by the caterpillars, the later flowers succeed into bolls (Appendix VIII). The plant cannot, however, be expected to stand this mutilation indefinitely and therefore it is fortunate that ultimately the population of the Spotted Boll-worms declines at the end of December or early in January and allows the cotton plants to complete their performance.

BEHAVIOUR OF THE COTTON PLANT WHEN IT IS GROWN FREE FROM BOLL-WORMS AND ESTIMATION OF THE IMPROVEMENT IN THE YIELD OF *KAPAS*.

Knowledge of the number of shoots destroyed or the amount of shedding of flower-buds and bolls, or even the exact counts of the number of larvae feeding on the plants every week, help but little to estimate the increased yield of *kapas* which should be available, if the boll-worms were absent from the cotton fields. As the economics of control depend upon this, it was necessary to resort to a direct method of studying the plants by growing them free from boll-worm attack.

Plant cages of wooden frames covered by wire gauze.

To exclude the worms from the plants, wooden cages were prepared, whose sides were 3 ft. in width and $4\frac{1}{2}$ ft. in height. The sides and tops of these cages were covered with zinc coated wire gauze, of 400 meshes to a square inch. The cages were permanently placed on single plants throughout the cotton-growing season (Plate VII, Fig. 1), and the plants were kept under observation.

In addition to these cages, a big permanent cage was constructed which was 15 ft. broad, 20 ft. long and 9 ft. in height. The sides and the top of this cage also were covered with similar wire gauze. This was big enough to accommodate 30 plants spaced 3 ft. by 3 ft. The plants under this cage also were kept under observation.

Within a few weeks, it was observed that all these cages were quite effective in keeping off the boll-worms and for a time it appeared that they would suit our purpose very well. It was, however, not very long before we realised that the plants enclosed in these cages were growing in an abnormal way. They appeared to be tall and lanky, and had thin broad leaves. Most of them reached the tops of the small cages very soon, and some of the plants in the big cage also, to our great surprise, reached its top, which was 9 ft. from the ground (Plate VII, Fig. 2).

In the face of such abnormal growth it was not possible to utilise these plants for getting a correct idea about the maximum capacity of yield of the plants when they were grown free from boll-worms. The need for a better method which would efficiently protect the plant from boll-worms, and at the same time allow them to grow quite normally, was very keenly felt.

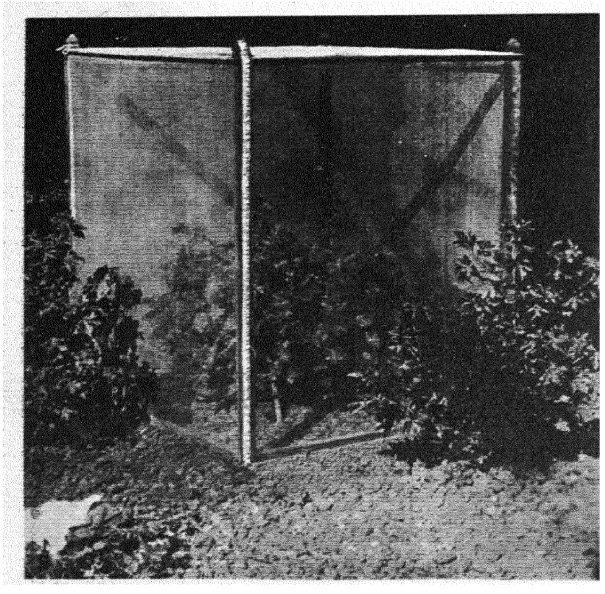


FIG. 1. Plant cage with wire gauze sides and top.

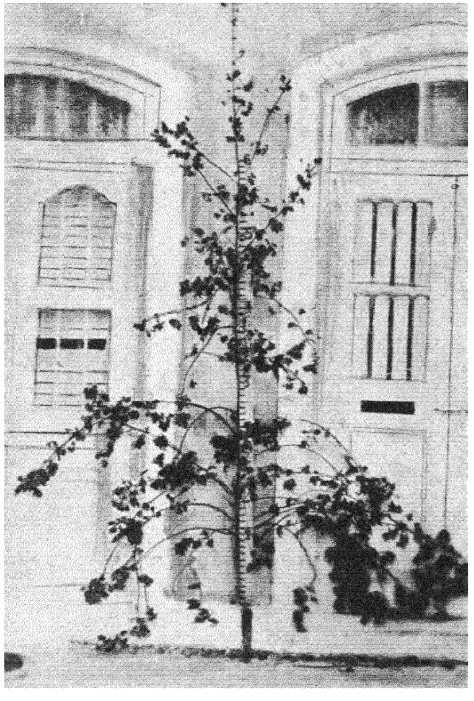


FIG. 2. Cotton plant grown free from boll-worms in a plant house with sides and top of wire gauze.

PLATE VIII.

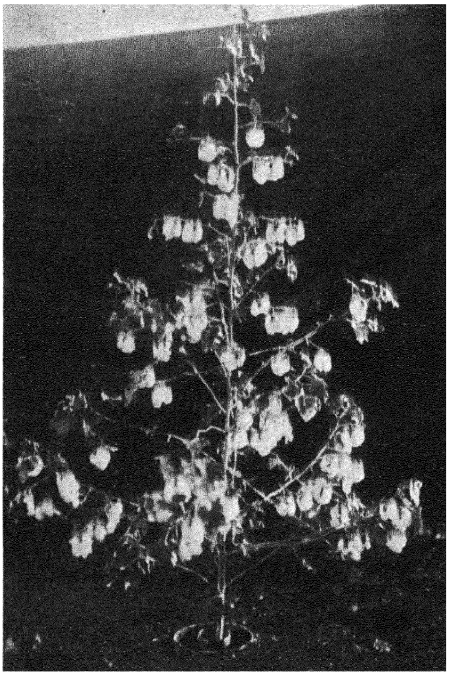


FIG. 1. A cotton plant grown free from boll-worm by night-caging. (Note the tin trench round the stem of the plant.)

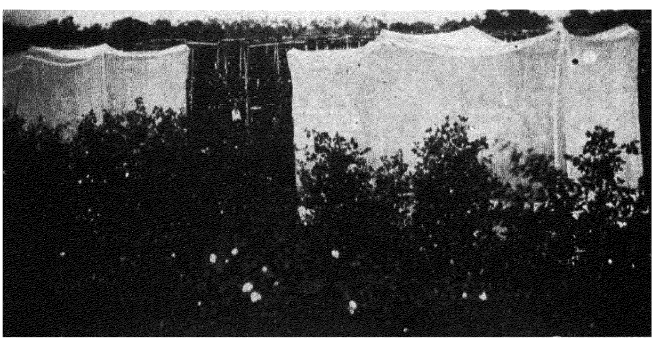


FIG. 2. Plant curtains used for night-caging.

Night-caging method

In the meanwhile, detailed work of the life-history and habits was in progress in the laboratory which afforded ample evidence that the Spotted Boll-worms were incapable of laying eggs, during the day time, and it was therefore needless to enclose the plants during the day for preventing oviposition by *Earias* moths. The permanent cages were therefore discarded, and it was decided to cage the plants during the night only. Night caging prevented the moths from laying eggs on these plants, but there still remained the possibility of the boll-worm larvae crawling from the non-caged to the caged plants. It was, therefore, necessary to keep small tin trenches, with water and oil in them, round the stem of each plant to catch the worms which would try to encroach. This new method has been hereafter referred to as " Night Caging " method, and its important details are enumerated below :—

(1) Light wooden cages are prepared and are covered with mosquito netting cloth on the sides and the tops. They are placed on the plants every evening before sunset and are removed every morning after sunrise.

(2) Small tin trenches 7 inches in diameter, 3 inches in height and having a circular opening in the centre (3 inches in diameter) for accommodating the stem of the plant, are prepared. These are slipped round the plants before they are 6 to 8 inches in height. A small quantity of water with a thin film of non-volatile oil (such as sesamum oil) is kept in the trenches for catching any of the larvae which may attempt to cross over to the plants selected for caging (Plate VIII, Fig. 1).

(3) The third essential for the success of the method is to shake the plants lightly every evening to drive away the moths, if there be any, before placing the cages, for the night.

To start with, only single plant cages were utilised for this method. It was, however, subsequently modified to cover 3 or 5 plants simultaneously under one cage. The wooden frame work was dispensed with, and iron pipes were fixed in the soil, round groups of plants and mosquito nets of suitable sizes were slipped on these supports (Plate VIII, Fig. 2).

The trenches and the nets were found to be quite effective in keeping off the boll-worms, and the plants grew quite normally as they received full ventilation during the day time. It must be mentioned that this device also prevented the attack of the shoot-roller (*Phycita infusella* Meyr.) and to a great extent of the Pink Boll-worm (*Platyedra gossypiella* Saund.) as well.

A few stray cases are, however, noticed of accidental infection by the boll-worms. The Pink Boll-worm moths especially are smaller in size and therefore they sometime create a good deal of trouble to the developing bolls. A careful watch has to be kept to detect such infection for removing it as soon as it appears.

Observations on the caged plants

Only ten plants were grown during each of the first two seasons (1925-26 and 1926-27) under night caging. During the third season (1927-28), 20 plants were

similarly grown. During all the three seasons complete records of the growth of the main stem, periodical flower-bud formation, and flower opening were maintained; and the proportion of the periodical flowers to the bolls which finally yielded the *kapas* was also worked out. All these observations were also maintained on an equal number of non-caged plants for comparison.

More extensive trials on a larger number of plants were subsequently undertaken during the next three seasons, especially for determining the yield of *kapas* in the absence of boll-worms. The observations during the first three seasons have helped to give a more or less accurate picture of the cotton plant as it would grow if the boll-worms are eliminated.

Growth of main stem and branches

It has already been mentioned that the tender vegetative shoots of the main stems, as well as, of the branches are destroyed in large numbers by the Spotted Boll-worms and shoot rollers, under normal field conditions. The caged plants, however, escape this injury, and as a result the height of their main stems is greater, and they have a larger number of primary sympodia than the control plants, so that ultimately the caged plants present a more regular conical appearance (Plate IX, Figs. 1 and 2).

Table XXIV

Number of primary sympodia per plant and the average height of the caged and the uncaged plants

	Year	Plants under observation	No. of primary sympodia per plant	Average height of main stems cms.
Caged	1925-26	8	26·8	89·0
Non-caged	1925-26	25	5·7	38·0
Caged	1926-27	10	23·0	82·7
Non-caged	1926-27	20	13·4	59·2
Caged	1927-28	18	29·1	109·0
Non-caged	1927-28	16	8·6	54·6

Formation and shedding of flower-buds and bolls

The flower-buds begin to appear about the same time both on the caged and the uncaged plants. During some of the seasons, most of the earliest formed flower-buds drop away, due to unfavourable environmental conditions, and then follows a period of rapid development of flower-buds. It is, however, about this time that

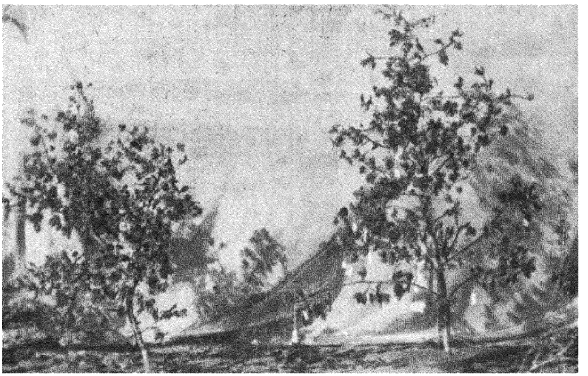


FIG. 1. Right:—Cotton plant protected from boll-worm by night-caging. Left:—Unprotected plant.

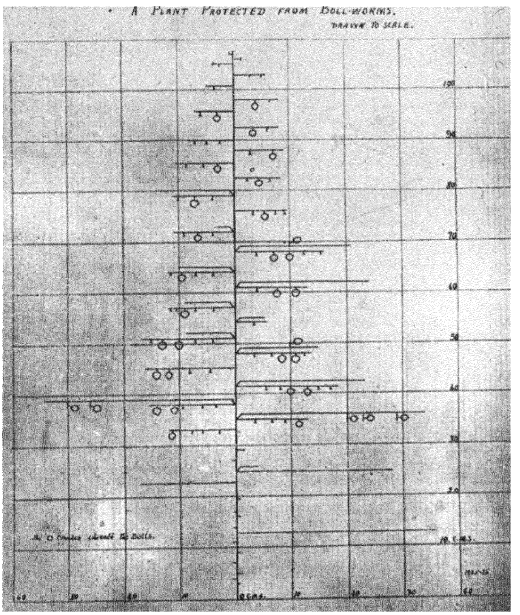
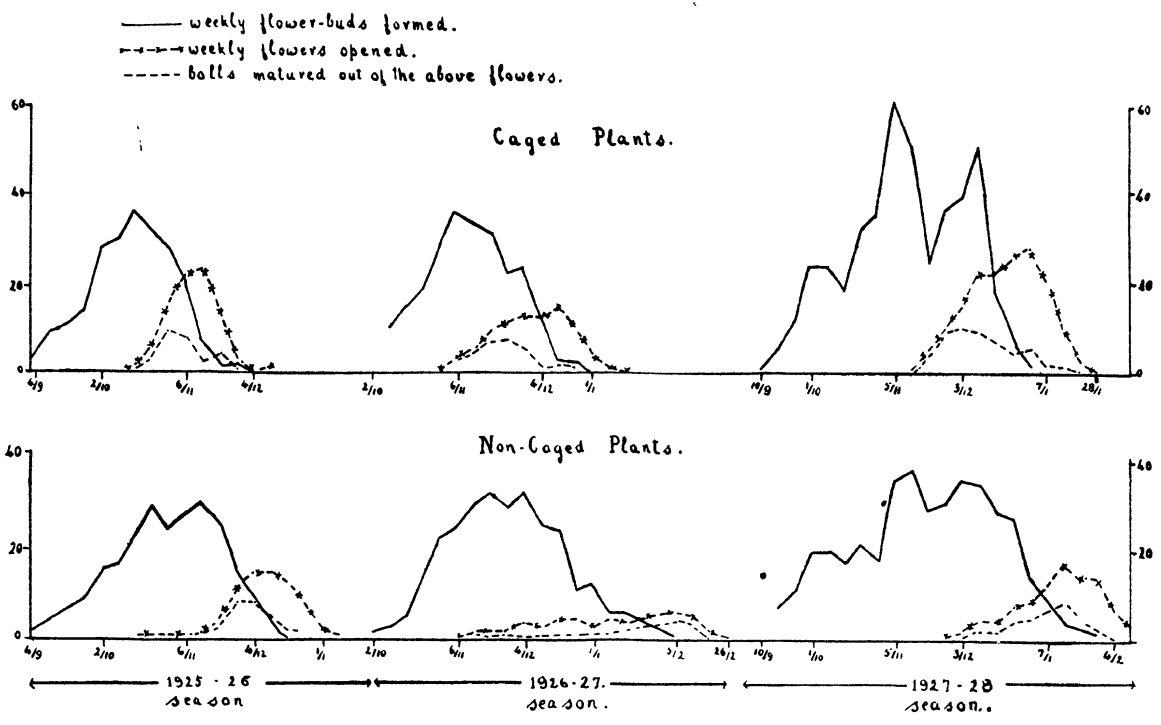


FIG. 2. Diagrammatic sketch of a cotton plant grown free from boll-worm by night-caging.

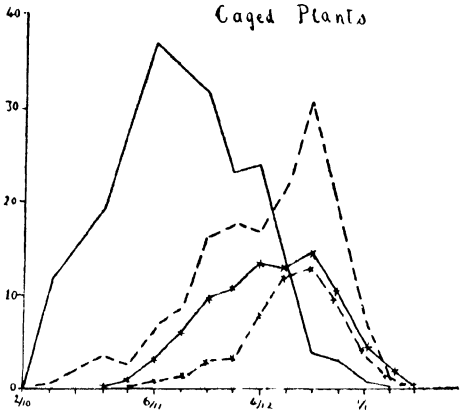
PLATE X.

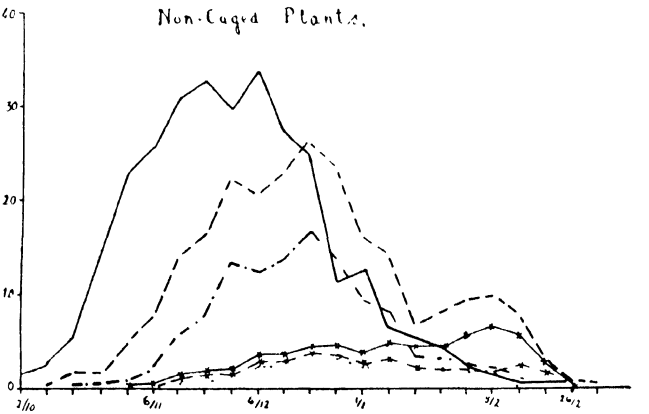


Showing weekly performance of caged and uncaged plants during three seasons at Surat.

PLATE XI.

1926-27.





——— weekly flower bud formation. —•—•— weekly flower opening

– – – – weekly shedding of flower-buds. —•—•—•— weekly boll shedding (relative).

– – –•– – weekly shedding of flower-buds, showing bollworm injury. · · · weekly boll shedding (relative) showing boll worm injury.

Showing weekly flower-bud formation, shedding of flower-buds, opening of flowers and shedding of bolls from caged and uncaged plants at Surat during 1926-27.

the Spotted Boll-worms begin their attack on the developing buds, and we have seen that the attacked buds shed in large numbers every week from the unprotected plants. In the absence of this damage the number of developing flower-buds on the caged plants soon increases, and an intense flowering can be seen on these plants very much earlier than in the case of the control plants (Appendix I, Tables XIV, XV and XVI).

Later on when the flowering commences on the uncaged plants, the earliest flowers and young bolls fall a victim to the boll-worms in large numbers and hence the boll-development is delayed. It is important to note that a very large percentage of the earliest flowers develops into mature bolls on the caged plants, whereas the success of early flowers into bolls is comparatively very low on the uncaged plants. It is also necessary to note that as soon as a certain number of bolls have begun to develop on the caged plants from the earlier flowers, the later flowers drop away in large numbers (Appendix I, Tables XVII to XIX). (Plate X.)

It can be seen from the tables mentioned above that the difference between the periods of flower-bud formation, flower-opening, and boll-development was very marked during 1926-27. This difference is shown in graph form in Plate XI.

The early intensity of flowering and a larger success from the first flowers naturally leads to an earlier crop of *kapas* from the caged plants, and in some years the *kapas* is ready for picking on the caged plants 4 to 6 weeks earlier than in the general cotton fields.

The numbers of flower-buds which open into flowers and of flowers which develop into mature bolls on the caged and the uncaged plants are analysed below:

TABLE XXV

(Plants spaced 3 feet by 3 feet)

—	No. of plants observed	No. of flower-buds formed per plant	No. of flowers opened per plant	Percentage of flowers to flower-buds	No. of bolls matured per plant	Percentage of mature bolls to flowers	Percentage of mature bolls to flower-buds
1925-26.							
Caged plants .	8	229	89	38·9	31	35 4	13 7
Control plants .	25	257	73	28 9	28	38·3	10·97
1926-27.							
Caged plants .	10	243	89	36·6	33·0	37·7	13·7
Control plants .	20	297	59	19·9	24 0	40·2	7·97
1927-28.							
Caged plants .	20	445	166	37·4	56	33·8	12·7
Control plants .	16	411	96	23·4	37	38·4	9·0

From column No. 4 of the above statement it is seen that during the 3 seasons under consideration, the percentage of flower-buds that opened into flowers on caged plants varied between 36·6 and 38·9, whereas in the case of the non-caged plants this percentage varied between 19·9 and 28·9. It will be evident from these figures that a very much larger proportion of flower-buds open into flowers on the cotton plants when they are protected from the boll-worms.

Column No. 6 of the same statement, however, indicates that the percentage success from flowers to mature bolls on the caged plants is slightly lower than on the non-caged plants. This is probably due to the fact that a disproportionately higher number of flowers open on the caged plants and hence the percentage of the flowers ultimately retained on them as mature bolls declines to a small extent. The ultimate success of the flower-buds into mature bolls on the caged plants, as can be seen from column No. 7 of the last statement, was higher than on the uncaged plants during all the three seasons. The percentage success of flower-buds to bolls on the caged plants during the three years varied between 12·7 and 13·7, whereas it varied between 7·9 and 10·97 in the case of the control plants.

The last column will further show that the caged plants produced 11 to 51 per cent more mature bolls than their controls during the three seasons under consideration. During 1927-28, *kapas* from these plants was weighed and it was found that the caged plants produced 100 grams of *kapas* per plant, and the uncaged plants 66 grams. The caged plants thus produced 52 per cent more *kapas* during that season.

20 plants were grown by night-caging on the Broach Farm during 1927-28 and parallel observations are given below :

TABLE XXVI

Caged and uncaged plants on Broach Farm

1927-28

—	Plants observed	Flower-buds per plant	Flowers per plant	Bolls per plant	Percentage flowers to flower buds	Percentage bolls to flowers	Percentage bolls to flower buds	Weight of *kapas* per plant (Tolas)
Caged plants . .	19	677	255	91	37 7	35·7	13 4	13·77
Non-caged plants .	12	530	177	66	33 4	37 3	12 5	8 31

These caged plants yielded about 25 bolls more per plant than their controls and produced about 66 per cent more *kapas*.

The observations, mentioned so far, though made on a small number of plants, clearly indicated that if the cotton plants could be grown free from boll-worms, they

would grow into better plants in various respects and would undoubtedly produce a larger number of bolls. The crop would besides be ready about 4 to 6 weeks earlier.

Night caging on a large scale

More extensive trials were undertaken during the next three seasons of 1928-29, 1929-30 and 1930-31 at Surat, in order to get a more significant idea about the increase in the yield of *kapas* which would result if the boll-worms were eliminated.

During each of the three seasons, a plot of about one acre was reserved for growing cotton, and the plants were spaced 4 feet by 4 feet. The plot was divided into three blocks, and the central block was used for caging the plants. More than 100 plants were marked out in groups of three, because each mosquito net could only cover 3 plants. A similar number of plants was also marked out in each of the two side blocks in groups of 3 plants, and these groups were located in the same design as in the central block.

These plants were not tampered with, for making any detailed observations, until the bolls matured. The *kapas* from sound and damaged locks from each one of these plants was collected and weighed separately.

Monsoon during the seasons, 1928-29, 1929-30, 1930-31

A note upon the peculiarities of the monsoon during the three seasons of these trials will be useful for a better understanding of the performance of the plants under observation.

During the season of 1928-29, the total rainfall was a good deal lower than in the other two seasons (Appendix I, Table VII). It was, however, well distributed, and, the rainfall during the months of July and August being moderate, conditions for vigorous growth of the plants prevailed during the earlier part of the season.

During the next year, 1929-30, out of the total of about 48 inches, 33 inches of rainfall was received during the first fortnight of July. This necessitated the resowing of cotton which was done on the 17th of July 1929.

In 1930-31 also the total rainfall exceeded 40 inches but it was very much better distributed. On the 29th of October, a severe storm passed over Surat accompanied by rainfall (95 cents) and in several plots even the cotton plants were lodged to the ground.

Growth of caged plants

Although detailed growth records of these plants were not maintained, the general observations showed that the caged plants during all the three seasons were much earlier in flower-bud and boll-formation than the uncaged plants, and finally it was possible to collect *kapas* from these plants about 4 to 6 weeks earlier than from the general field plants (Appendix I, Table XX).

TABLE XXVII

Period of picking of kapas *from the caged and uncaged plants*

Year	From caged plants	From uncaged plants
1928-29	7th January 1929 to 7th March 1929.	8th February 1929 to 22nd March 1929.
1929-30	1st January 1930 to 11th February 1930.	20th February 1930 to 24th March 1930.
1930-31	5th January 1931 to 10th March 1931.	20th February 1931 to 19th March 1931.

During the first two seasons the effective crop of *kapas* from the caged plants was collected before the end of February. It was slightly delayed during 1930-31 due to the storm of 29th October 1930 which destroyed a very large number of developed flower-buds and bolls from the caged plants. It was, therefore, seen that normally January and February would be the months of harvesting of *kapas* instead of February and March if the crop is saved from the boll-worms.

When all the pickings were over, all the plants from the cages and the Northern control were cut at the cotyledonary nodes and were hung up in the fields for being dried for about 3 weeks, and their air-dry-weights were recorded. All the remaining leaves from these plants were nipped out before cutting the plants.

The weights of these plants were recorded for comparing the growth of the caged and uncaged plants and for comparing the *kapas* produced by these plants in relation to their final dry weights.

TABLE XXVIII

Dry weight of scaffolding and crop

	No. of plants observed	Average dry weight of plants in grms.	Average weight of *kapas* per plant in grms.	Amount of *kapas* produced to unit dry weight
1928-29.				
Caged plants	89	204·0	236·6	1·16
Uncaged plants	104	137·3	130·6	0·95
1929-30.				
Caged plants	113	92·1	174 0	1·89
Uncaged plants	112	99·2	113·2	1·14
1930-31.				
Caged plants	118	98·7	159·7	1·62
Uncaged plants	116	126·2	150·0	1·19

It was found that during the first season the dry weight of the caged plants was distinctly higher than the controls. Their weights did not differ to a great extent during the second season, but during the third season the dry weight of the caged plants was distinctly lower. The capacity of the caged plants for producing *kapas* per unit dry weight, or, in other words, the yield efficiency of the caged plants for a given weight of their expanse, was higher during all the seasons and was particularly marked during the last two seasons.

Increased yield due to caging

The caged plants produced more *kapas* than the control field plants during all the three seasons. This increase, however, varied considerably. During 1928-29, the caged plants yielded 81 and 102 per cent more *kapas* than the two controls respectively. During the next season this increase over the control plants amounted to 53 and 54 per cent and during the third year of these trials, the caged plants produced only 6·5 and 15 per cent more *kapas* than each of the two sets of controls respectively.

Table XXIX

Yields of caged and uncaged plants at Surat

—	1928-29			1929-30			1930-31		
	Plants observed	*Kapas* per plant in grms.	Percentage increase of yield over control plants	Plants observed	*Kapas* per plant in grms.	Percentage increase of yield over control plants	Plants observed	*Kapas* per plant in grms	Percentage increase of yield over the control plants
Caged plants .	99	236 6		113	174 0		118	159 7	
Uncaged plants (North-control)	104	130 6	81 per cent over the North Control	112	113 2	54 per cent over the North Control	116	150 0	6 5 per cent over the North Control.
Uncaged plants (South control).	100	117 4	102 per cent over the South Control.	112	113 8	53 per cent over the South Control.	118	138 5	15 per cent over the South Control

Increase in the yields of caged plants in relation to the incidence of boll-worms and other environmental conditions

It might be expected that the differences in yield, between the plants, protected and unprotected from the boll-worms, should vary according to the intensity of the

infestation of the Spotted Boll-worms; and that it may therefore be inferred that the incidence of the boll-worms was the highest during 1928-29 and the least during 1930-31. A careful scrutiny of the weekly records of the population of the Spotted Boll-worms in cotton fields (Table XXII) will not, however, warrant such an inference. In fact the observations show that the intensity of infestation by the Spotted Boll-worms was almost similar during the last two seasons, and that it was a little lower during 1928-29, when the highest differences between the caged and the non-caged plants were recorded.

Information upon the incidence only of the Spotted Boll-worms is insufficient to account for the seasonal differences between the plants, protected and unprotected from this pest, and it is necessary to study the variations in the other environmental conditions as well. It was not within the scope of this enquiry to study in detail the effect of all the various environmental conditions on the plant growth; but the outstanding factors which apparently affected the differences between the caged and uncaged plants must be briefly discussed.

It has been shown that flower-bud formation, flower opening and boll-development take place very much earlier on the caged than on the uncaged plants, and that their *kapas* can be collected about 4 to 6 weeks earlier. This means that the caged plants pass through all their stages of growth a few weeks earlier than the control plants, and consequently the environmental conditions of soil and climate at the various stages of life of both sets of plants are not identical.

Generally, the soil and climatic conditions are more favourable for plant growth during the earlier part of the growing season, and they, therefore, help to increase the differences between the caged and the uncaged plants.

During the month of July at Surat heavy showers of rain are usual, which cause water logging of the soil. These heavy showers were not received during 1928. The total rainfall of the season was not very heavy and it was well distributed. Conditions for plant growth were therefore favourable during the early part of this season, and consequently the caged plants grew vigorously, and ultimately their average dry weight was found to be 204 grams per plant, *i.e.*, about twice the average weight for the other two seasons. The uncaged plants also flourished during this period but their growth was hampered, and their period of flower-bud formation and boll development was delayed, due to the damage caused by the Spotted Boll-worms during the months of September, October and November. They could not, therefore, take full advantage of the favourable environmental conditions which were available during the early part of the season. There was, therefore, a wide difference between the yields of the caged and uncaged plants during this season.

During the next season, there was a very heavy rainfall during July, and the conditions were not quite as favourable for very early growth as during the previous season. The conditions, however, improved considerably after the end of July, and ultimately the caged plants yielded about 54 per cent more *kapas* than their

controls although the final air-dry-weight of the caged plants was slightly less than that of the uncaged plants.

In 1930-31, the caged plants were progressing quite satisfactorily, and flower-opening had commenced on these plants during the month of October, when flower-buds had just commenced to develop on the uncaged plant. A storm passed over Surat on the 29th of October and all the plants were rudely shaken and a few of them had their branches broken. The result of this storm was more disastrous to the caged plants because they had very much advanced in growth and therefore lost many of their developed forms. During the period of about 5 or 6 days after the storm, 8,105 shed flower-buds and 2,520 young shed bolls were collected from all the caged plants. Thus the caged plants after having lost most of their developed forms, had to begin afresh, practically even with the non-caged plants, and hence the difference in the yields of the two sets of plants was meagre.

It is, therefore, seen that the other environmental conditions play an important part in increasing or decreasing the seasonal differences in yields of *kapas* from the plants protected and un-protected from the boll-worms. The balance in favour of the boll-worm free crop may be masked, in abnormal seasons, by the depressing effect of other factors in the environment.

Caged plants and the red cotton bug

Red cotton bug (*Dysdercus cyngulatus*) is not a serious pest at Surat. However, it was found that in November 1929, a large number of these bugs began to appear only on the caged plants, and their numbers increased considerably during the month of December. Nearly 1,450 were collected from the caged plants during that season to save the developed bolls from their injury. In 1930-31, again a very large number appeared on the caged plants during boll development period, whereas they were rarely noticed on the general crop.

The apparent reason for this concentration is that the bugs prefer well developed bolls for their attack, and a large number of these are found on the caged plants at a time when such bolls are rarely met with on the general crop.

Caging and the quality of *kapas*

It has already been stated that the *kapas* from the sound and the damaged locks from all the bolls of the caged and the uncaged plants was collected and weighed separately. The damaged *kapas* consisted of locks which did not develop normally, either due to the damage of the boll-worms (*Earias fabia*, *Earias insulana* and *Platyedra gossypiella*), or due to other causes.

TABLE XXX

Proportion of kapas *from sound and damaged locks*

	Saleable *kapas* per plant in grams		Total *kapas* per plant in grms.
	From sound locks	From damaged locks	
1928-29.			
Caged plants	221 1	15·4	236·5
Control plants	105 5	25 1	130 6
1929-30.			
Caged plants	171 8	2 2	174·0
Control plants	107·9	5 3	113 2
1930-31.			
Caged plants	152·2	7·9	160·1
Control plants	140 7	9 4	150·1

A further classification of the number of locks which yielded saleable and unsaleable *kapas*, and which were partially or completely destroyed by the boll-worms, will be found in Appendix I, Table XXI.

After the pickings of *kapas* from the caged and the uncaged plants were over during 1929-30, we found that the *kapas* from the caged plants appeared distinctly coarser. All the *kapas* from the good locks from both the groups of plants was, therefore, ginned and it was found that the ginning percentage of the *kapas* from the caged plants was 37·3, whereas it was 34·4 in the case of the *kapas* from the uncaged plants.

This difference was naturally attributed to the fact that the environmental conditions for the development of bolls from the caged and uncaged plants were not identical.

In order, therefore, to get a better idea of the effect of caging on the quality of *kapas*, all the lint from the good locks of the caged and the uncaged plants, grown during 1929-30 and 1930-31, was sent to the Matunga Technological Laboratory for spinning tests. The detailed reports are given in Appendix II.

It will be seen from these reports that the lint from the caged plants of 1929-30 was valued at Rs. 150 over the contract rate, whereas the control sample from the

uncaged plants was valued at Rs. 120 over the contract rate. The lint from the caged plants of 1930-31, however, was valued at Rs. 70 over the contract rate, whereas value of the control sample of that season was Rs. 75 over the contract rate.

It is also interesting to note that the staple length of the lint from the protected plants was full $1\frac{3}{8}$ inch, whereas it was $1\frac{1}{8}$ in the case of the lint from the control plants of 1929-30. There was, however, no difference in the staple length of the two samples during the next season.

In spite of all this, it is essential to remember the concluding remarks of the Director of the Technological Laboratory, Matunga. In his first report, he says " The lint from the caged plants, though possessing a somewhat longer staple, is decidedly coarser and rather inferior in spinning performance to the lint from the control plants."

In short, the various observations mentioned in this chapter have shown that if the cotton crop were saved from the Spotted Boll-worms, not only would damage to the various parts of the cotton plant prevented but the crop would be able to make full use of the environmental conditions for growth which are generally more favourable during the earlier part of the growing season ; and that the crop would be ready earlier by about 4 to 6 weeks with the ultimate result that we could normally expect a substantial increase in the production of *kapas*.

STUDY OF CONTROL MEASURES

In the introductory chapter reference was made to some of the control measures, which were advocated by the previous workers. Destruction of the affected cotton shoots at the commencement of the cotton-growing season, use of *bhendi* (*Hibiscus esculentus*) as a trap crop and introduction of parasites were some of these measures. To study their efficacy under the conditions of this tract was, therefore, a part of the programme at the commencement of these investigations.

1. Removal of attacked shoots

It has already been stated that it is with the cessation of the monsoon that the cotton plant begins to grow vigorously in this tract, and it is then that the Spotted Boll-worms begin to multiply rapidly. A majority of the population of these worms, during the first few weeks of this growing period is found feeding on the tender vegetative shoots (Appendix I, Tables VIII to XIII). Many of the larvae bore into the succulent top internodes and destroy the shoots, which wither and dry up. It was, therefore, necessary to discover whether, if the attacked shoots were collected and destroyed, the further progress of the pest would be checked to a considerable extent.

Two experiments were, therefore, laid out during 1925-26. In the first, an area of one acre was kept under observation during the whole of the period in which the attack was concentrated on shoots. All the attacked shoots, which could easily

be observed by an ordinary labourer from the appearance of the withering tops, were collected once a week and were examined to note the number of *Earias* larvae in them. In the second experiment, a fresh group of 1,000 plants was examined, a little more critically than in the previous case, and all the withering shoots as well as those which showed holes bored by the boll-worms prominently were collected for examination. The number of larvae found every week was compared with the number which was expected to be present. The probable population in these plots was calculated from the number of larvae which were recorded in an exhaustive weekly examination of 25 cotton plants. (Appendix I, Table VIII.)

TABLE XXXI

Number of Earias *larvae collected from shoots from the two plots and the expected population of larvae from each of them*

Weeks	Total population of *Earias* larvae from 25 plants	One acre plot (about 4,800 plants)			1,000 fresh plants every week		
		Withered shoots	No. of *Earias* larvae	Expected population of *Earias* larvae	Attacked shoots	No. of *Earias* larvae	Expected population of *Earias* larvae
19th September 1925 .	32	86	25	6,144	282	139	1,280
26th September 1925 .	48	53	19	9,216	313	154	1,920
3rd October 1925 .	48	33	6	9,216	240	94	1,920
10th October 1925 .	43	27	6	8,256	248	132	1,720
17th October 1925 .	68	25	5	13,056	178	97	2,720
24th October 1925 .	87	41	15	16,704	232	104	3,480
31st October 1925 .	73	21	3	14,016	194	88	2,920
7th November 1925 .	45	16	*Nil*	8,640	131	30	1,800

The comparison showed that the number of larvae removed from the plot of an acre was almost insignificant, compared with the population expected to be present in that area and the number of larvae collected from a fresh group of 1,000 plants every week showed that hardly ten per cent of the total population of the boll-worms, calculated from the detailed examination of twenty-five plants, would be destroyed even on careful search.

It is thus seen that only such shoots, whose damage can be easily noticed, can be collected by this method, and that there is a very large percentage of population

which remains over in the fields as the damage caused by them is not easily perceptible. Much significance cannot, therefore, be attached to this method of controlling the Spotted Boll-worms by collecting and destroying such of the attacked shoots as can be easily observed by the cultivators.

2. Trap crops

Bhendi (*Hibiscus esculentus*) is known to be a favourite food plant of the Spotted Boll-worms, and its cultivation in the cotton fields has been advocated for trapping these worms. [Javeri, 1921]. It was therefore necessary to ascertain the effect of using this trap crop as a control measure.

In most of the villages round about Surat, *bhendi* is grown at the commencement of the monsoon and large quantities of *bhendi* pods are available in the Surat market during the months of August and September. The plants from these plots are severely attacked by the Spotted Boll-worms, and by the month of October even the pods which are sent to the market from these plots show a considerable amount of infestation.

Table XXXII

Bhendi *pods purchased from the Surat market*

Date of examination	Weight of the pods examined	No. of pods examined	No. of *Earias* larvae
10th August 1929	3	144	1
17th August 1929	5	271	4
24th August 1929	5	181	5
31st August 1929	5	215	6
6th September 1929	5	213	7
13th September 1929	10	388	18
20th September 1929	10	443	27
28th September 1929	5	202	30
4th October 1929	5	209	22
12th October 1929	5	259	55
15th October 1929	5	229	69

The plants from these plots finish their life by the end of October just when the cotton plants begin their vigorous growth and the Spotted Boll-worms begin to

increase in the cotton fields. All the *Earias* population liberated from the *bhendi* plots naturally transfers its attention to the neighbouring cotton crop.

What actually happens is that the good pods are picked out and the affected pods mostly remain on the plants, and even if the plants are destroyed at the end of the season along with the larvae feeding on them, the pupae in the soil and the adult moths at any rate escape destruction.

Observations at Jalgaon (East Khandesh) during 1929 showed that a few rows of *bhendi* were generally sown in the cotton plots, and that these plants grew luxuriantly and had a large population of Spotted Boll-worms on them (Appendix IV, Table II). Further it was noticed that in Khandesh the life of the *bhendi* plants was over long before the cotton crop was ready and the result was that the *Earias* population on the cotton crop suddenly increased as soon as the *bhendi* crop was over (Appendix IV, Table I and Plate XXII). Similar observation during 1930 showed that the *Earias* population on monsoon *bhendi* was meagre during the months of August and September due to heavy rainfall, and consequently the increase of the Spotted Boll-worms on cotton was more gradual than during the previous season.

It was, therefore, considered that the method of growing *bhendi* in the midst of cotton areas was harmful to the cotton crop, and it was probable that *bhendi* as a trap crop would only be useful if it continued its life and trap these worms till the cotton crop was over; or at least till the end of December when the *Earias* population normally declined.

Different varieties of *bhendi* were, therefore, tried both at Surat and Jalgaon for selecting a type which would be most suitable as a trap crop. An attempt was also made to sow these varieties late in the season in order to delay their growing period. The names of the varieties are given below :—(1) Surat 5, (2) Surat 9, (3) Katai *bhendi* (from Khandesh), (4) American long green, (5) American dwarf green and (6) American white velvet. In Jalgaon in addition to these varieties "Nasik" *bhendi* was also tried.

Late sowings

At Surat the first sowing of *bhendi* was done on the 26th of June, and these plants came on well. The plants sown in the middle of July made fairly good growth. The germination, however, was very defective in the case of sowings made after the middle of August, and the plants which germinated were very poor in growth.

In Khandesh also the June sowing was successful but the later sowings, which were repeated every fortnight, gave very poor germination and the growth of the few plants which germinated was very poor.

Comparison of the varieties grown at Surat

All the varieties, except the Katai *bhendi* suffered heavily from the attack of Jassids, which commenced from the middle of August and continued till the end

of September. Aphis infestation also appeared on these plants during this period but was soon checked by lady-bird beetles.

It was further noticed that manuring was necessary at Surat to secure satisfactory growth of these plants. The plants which were manured at the time of sowing with castor cake grew satisfactorily, whereas the plants from the un-manured plots remained stunted.

Twenty-five plants of each of these varieties were kept under observation and the mature pods from these plants were collected, as they became ready, and were examined for *Earias* larvae (Appendix I, Tables XXII, XXIII and XXIV).

Surat 9 began to yield pods in the last week of August, while pods could be collected from Surat 5 from the 5th of September. Surat 5 and Katai *bhendi* from manured plots continued to yield pods practically till the end of January and many of these pods were infested by boll-worms. Katai *bhendi* is a hardy plant with rough leaves and pods. It is a shy bearer and attracts a smaller number of Spotted Boll-worms than the other types.

All the American varieties turned out to be very late and began to bear pods at Surat from the beginning of December, and continued till the end of January.

On the whole it appeared that Surat 5, if manured at the time of sowing, would continue to trap the worms almost throughout the cotton-growing period and would therefore be a suitable type for trying as a trap crop at Surat.

Varieties tried in Khandesh

At Jalgaon, Nasik type of *bhendi* was the earliest to bear pods and to attract the *Earias* boll-worms. Nasik and Surat 9 finished their life at the end of October, whereas Surat 5 continued to bear till January. The American types began to bear at the end of September and continued till January (Appendix I, Tables XXV, XXVI and XXVII).

It appeared that it would be necessary to sow a mixture of Nasik and Surat 5, or Nasik and one of the American varieties, at the commencement of the monsoon to get a continuous stand of *bhendi* plants for trapping the boll-worms.

Infestation on cotton surrounded by *bhendi* plants

These trials indicated a possibility of securing a continuous stand of *bhendi* plants during the cotton-growing season but it was necessary to judge the extent of *Earias* population on the cotton plants growing in close proximity of *bhendi*. A plot of cotton (of about 10 *gunthas*) was laid out at Surat surrounded by two rows of Surat 5, and two rows of Surat 9. The population of *Earias* larvae from 25 plants of cotton from this plot, was determined thrice during the season. Similar population records, from 20 plants each time, were available for comparison from a distant plot of cotton in the same field.

TABLE XXXIII

25 PLANTS FROM PLOT SURROUNDED BY *bhendi*					20 PLANTS FROM A DISTANT PLOT OF COTTON				
Date of examination	No. of flower-buds	No. of *Earias* larvae in flower-buds	No. of bolls	No. of *Earias* larvae in bolls	Date of examination	No. of flower-buds	*Earias* larvae in flower-buds	No. of bolls	*Earias* larvae in bolls
4th November 1930	298	23	..	..	31st October 1930	290	24	..	..
3rd December 1930	1,988	41	..	..	29th November 1930.	1,474	22	..	..
10th January 1931	1,572	8	1,050	13	3rd January 1931	2,187	6	728	9
Percentage of flower-buds with *Earias* larvae=1·8. Percentage of bolls with *Earias* larvae=1·2.					Percentage of flower-buds with *Earias* larvae=1·3. Percentage of bolls with *Earias* larvae=1·2.				

These results showed that the attraction of *bhendi* was not strong enough to reduce the infestation on the neighbouring cotton plants. On the contrary, it appeared to be slightly higher; probably because the moths attracted to the *bhendi* plants infested the neighbouring cotton plants as well.

THE UTILITY OF *bhendi* AS A TRAP CROP

Bhendi is no doubt a favourite food of the Spotted Boll-worms, and a large number of these insects can be collected from these plants. If a short season variety is grown at the commencement of the monsoon, it helps to breed a very large number of *Earias* population, and the destruction of these plants with *Earias* larvae and eggs still leaves the pupae and the moths to continue the damage to the cotton crop. It has been found possible to secure a continuous stand of *bhendi* plants during the cotton-growing season, but the attraction of *bhendi* is not so strong as to prevent the infestation on the neighbouring cotton plants.

It would, however, be very difficult to ensure concerted action from the cultivators in picking out and destroying the affected *bhendi* pods at regular intervals before the larvae feeding on them go to the soil for pupation.

It has been shown that *bhendi*, being a more suitable food for these worms, accelerates the multiplication of this pest (page Nos. 9 & 10). Besides this, experience at Surat showed that *Earias* larvae feeding on *bhendi* plants were practically immune from the attack of the two important parasites, *viz.*, *Microbracon lefroyi* and *Actia aegyptia*. Time after time, large quantities of *bhendi* pods were examined during the course of the work of nearly seven years, but the presence of a caterpillar of *Earias*, attacked by *Microbracon lefroyi* or *Actia aegyptia* in these pods was extremely rare, even at a time when the parasites were abundant in the cotton fields. This naturally afforded more favourable conditions for the increase of this pest.

While no definite conclusion, that *bhendi* is effective as a trap crop in the control of *Earias* boll-worms, can be stated upon trials restricted to a single season, the indications are against the possibilities of its successful use and that the disadvantages of growing these plants in the midst of cotton areas would be greater than the advantages.

3. Parasites of the Spotted Boll-worms

The following seven parasites of the Spotted Boll-worms were found during our investigations at Surat.

(1) *Trichogramma* sp.
(2) *Microbracon lefroyi* D. and G.
(3) *Rhogas testaceous* Grav.
(4) *Actia aegyptia* Vill.
(5) *Apanteles* sp.
(6) *Chelonus* sp.
(7) *Melcha nersei* Cam.

We are indebted to M. A. Husain (Punjab) for the identification of most of these parasites.

All the important parasites of the Spotted Boll-worms, noted in other provinces, were thus present in this tract also, and there were no chances, therefore, of importing and establishing a new parasite from any other locality to effect control in Surat.

Observations during the first two or three seasons at Surat showed that the population of the Spotted Boll-worms in the cotton fields considerably declined every year at the end of December. At first though it appeared that the decline was purely due to the cold weather; but it was also observed that during November and December the following three parasites were active at Surat; and therefore, it was considered that the reduction in *Earias* population must be partly, if not wholly, due to the activities of these insects—

(1) *Rhogas testaceous* Grav.
(2) *Actia aegyptia* Vill.
(3) *Microbracon lefroyi* D. and G.

It was, therefore, decided to study the life and habits of these parasites.

Rhogas testaceous Grav.

This parasite is present throughout the year in the cotton fields at Surat, except during July and August. During September and October 1925, out of 1,014 *Earias* larvae collected, 22 caterpillars (*i.e.*, about 2 per cent) were attacked by this parasite.

A few attempts were made to observe the behaviour of this parasite in captivity. Pairs of the adult parasites were placed in round glass jars about 4 inches in diameter and 5 inches in height. Host larvae of different sizes were offered to the parasites, but it was found that they preferred only the small ones, which were only 3 or 4 days old, for laying eggs. The parasite repeatedly stung the larva until it was fully paralysed and then thrust its ovipositor in its body and laid a single egg. Each female laid only 2 or 3 eggs in a day. The larva recovered within a few minutes and began to feed. In September the parasite larva became fully fed within 6 to 8 days after the egg was laid, and was ready to pupate. At this time the host larva succumbed and the parasite pupated in its body. The body of the host caterpillar

swelled to accomodate the full grown parasite and hence its intersegmental chitin was exposed. Before the host caterpillar succumbed, it generally came out of the bud or boll where it was feeding, and fastened itself to a bract of a flower-bud or flower, or to any other part of the plant. From the time of the death of the host larva, it took about 7 to 9 days for the adult parasite to emerge. Thus the whole life-cycle took about 13 to 17 days during September and October. Such parasitised caterpillars could often be seen in the cotton fields and they could be easily recognised by their characteristic appearance. This parasite cannot be considered to be a very important one as its capacity for multiplication is found to be very low.

Actia aegyptia Vill.

This fly was observed at Surat for the first time in November 1923, and it continued to breed till the end of July 1924. It reappeared again in October 1924 and was found to increase in numbers till the end of December 1924. It generally appeared every year in October or November when the *Earias* larvae began to feed on the flower-buds. During September and early in October a large number of *Earias* larvae were feeding on the shoots of the cotton plants but only one larva parasitised by this fly was found in the shoots. So also the *Earias* larvae in *bhendi* pods were never found attacked by this fly, although a very large population of these worms was present on the *bhendi* plants when this parasite was active in the cotton fields.

During September and October 1925, of 1014 *Earias* caterpillars, 69 were found to be parasitised by this fly. Both *Earias fabia* and *Earias insulana* were attacked by this parasite.

All attempts to breed this parasite in the laboratory failed and further information about its life and habits could not be secured.

Microbracon lefroyi D. and G.

This has been a well-known parasite in India since Lefroy recommended its importation in the Punjab after the failure of the cotton crop in 1905 [Lefroy 1906, 2].

In Bombay Presidency the presence of this parasite has been noted in Gujarat, in Khandesh, in Karnatak and in Jamrao canal tract of Sind.

Life of the adult.—The average life of the adult was found to vary from about 11 to 31 days during the different months at Surat. During November and December some of the adults lived for 58 and 59 days, *i.e.*, for nearly 2 months.

Mating generally takes place on the day of emergence, or on the second day, and is repeated several times during the period of their life. No eggs are laid by the female wasp on the day of its emergence, and frequently a week or more elapses before oviposition commences under laboratory conditions, but it is not known if such an interval exists under natural conditions also. Normally oviposition begins on the second or third day after emergence of the female. Eggs are laid parthenogenetically also, but in such cases the progeny consists of males only.

TABLE XXXIV

Period of adult life of Microbracon lefroyi *D. and G.*

Month of emergence of the parasite	No of cases observed	Average life in days	Maximum life of an adult in days
August 1926	2	14	21
September 1926	17	12	21
October 1926	29	15·6	38
November 1926	40	22	58
December 1926	17	31	59
January 1927	9	25	48
February 1927	22	26·6	41
March 1927	10	15	27
April 1927	3	11	22

Occasionally a few female parasites refused to lay eggs in captivity, although they continued to live for several days.

Oviposition.—The eggs are laid at any hour of the day time but the parasites are most active in the morning between 8 to 10 A.M.

Only fully grown *Earias* caterpillars are selected for oviposition, and both *Earias fabia* and *Earias insulana* are attacked. The host larvae are completely paralysed before eggs are laid. *Earias* caterpillars, freely moving about in the cage, were never attacked by these parasites. Oviposition was observed only when the host larvae were enclosed in their food, such as a piece of *bhendi*, a flower-bud or a boll.

The female parasite locates the larva, which is not visible from outside, by tapping the food with its antennae. She then inserts her ovipositor through the hole through which the host larva has entered the food, or if the food material is sufficiently tender, the ovipositor is thrust through the material, and the caterpillar is paralysed. The eggs are then laid in groups of 2 or more on each larva. Instances of caterpillars with single eggs are also noticed but more than one is the general rule. The largest number of eggs laid on a single *Earias* caterpillar was found to be 22, while the largest number of eggs laid by a single parasite in one day was 40.

A few living *Microbracon lefroyi* were secured from Khandesh and the Punjab, and were bred separately at Surat. The capacity of multiplication of all these parasites from different localities are shown in the following tables. The number of eggs laid by these parasites was recorded only in a few cases because the material had to be disturbed for counting the eggs, and often the eggs got dislodged from the body of the host larva. From Table XXXVI it will be seen that the female parasite from pairs No. 14 and 16 laid 310 and 504 eggs respectively. There is a great variation in the number of adults obtained from each pair, which is probably due to the susceptibility of the parasites to the unnatural conditions of breeding captivity.

TABLE XXXV

Reproductive capacity of Khandesh Microbracon lefroyi *in Surat in 1925*

PERIOD OF OBSERVATION		Pair No	No. of eggs laid	Pupae	Males	Females	Total adults
From	To						
25th August 1925 .	12th September 1925	1	55	55	23	25	48
28th August 1925 .	19th September 1925	2	87	67	20	38	58
28th August 1925 .	7th September 1925	3	65	63	13	43	56
28th August 1925 .	6th September 1925	4	16	9	2	7	9
3rd September 1925 .	27th September 1925	5	64	60	22	33	55
3rd September 1925 .	14th September 1925	6	64	58	12	38	50
5th September 1925 .	23rd September 1925	7	..*	66	10	43	53
9th September 1925 .	26th September 1925	8	..	50	6	16	22
9th September 1925 .	28th September 1925	9	..	68	19	37	56
10th September 1925	21st September 1925	10	..	37	9	21	30
13th September 1925	5th October 1925 .	11	..	34	8	20	28
13th September 1925	25th September 1925	12	..	27	..	15	15
14th September 1925	6th October 1925 .	13	..	63	24	16	40
15th September 1925	3rd October 1925 .	14	..	37	18	9	27
16th September 1925	21st September 1925	15	..	32	8	10	18
16th September 1925	30th September 1925	16	..	22	17	4	21
17th September 1925	3rd October 1925 .	17	..	28	19	5	24
24th September 1925	5th October 1925 .	18	..	36	8	23	31
27th September 1925	12th October 1925 .	19	..	16	2	8	10
26th September 1925	1st October 1925 .	20	..	13	8	2	10
28th September 1925	16th October 1925	21	..	5	4	1	5
2nd October 1925 .	16th October 1925	22	..	25	3	10	13
2nd October 1925 .	7th October 1925 .	23	..	6	1	3	4
2nd October 1925 .	5th October 1925 .	24	..	6	5	..	5

Parasites refused to lay eggs after the middle of October.
* Egg counts taken in first six cases only.

TABLE XXXVI

Reproductive capacity of Microbracon lefroyi *at Surat*

(*Parasites obtained locally.*)

1924-27

PERIOD OF OBSERVATION		Pair No.	No. of pupae	No. of males	No. of females	Total adults	REMARKS
From	To						
27th October 1924 .	17th November 1924	1	35	6	21	27	
30th October 1924 .	4th November 1924	2	4	..	4	4	
30th October 1924 .	13th November 1924	3	82	36	26	62	
5th November 1924 .	24th November 1924	4	48	12	23	35	
5th November 1924 .	22nd November 1924	5	35	26	..	26	
13th November 1924	6th December 1924	6	141	36	58	94	
15th November 1924	23rd November 1924	7	12	4	4	8	
15th November 1924	3rd December 1924	8	131	59	44	103	
16th November 1924	24th November 1924	9	30	23	..	23	
24th November 1924	28th November 1924	10	8	5	..	5	
26th November 1924	13th December 1924	11	18	8	..	8	
26th November 1924	18th December 1924	12	52	42	..	42	
26th November 1924	18th December 1924	13	41	31	..	31	
29th January 1925 .	12th March 1925 .	14	125	35	64	99	Eggs laid 310
24th February 1925	19th March 1925 .	15	38	13	15	28	Do. 95
30th April 1925 .	21st May 1925 .	16		not	noted		Do. 504
25th November 1926	10th January 1927 .	17	..	70	66	136	
25th November 1926	1st January 1927 .	18	..	40	50	90	
28th November 1926	8th January 1927 .	19	..	37	59	96	
2nd January 1927 .	22nd February 1927	20	..	68	54	122	

The last two were mated with the Punjab males to see if they interbreed.

TABLE XXXVII

Reproductive capacity of the Punjab Microbracon lefroyi *in Surat in 1926-27*

Period of observation		Pair No.	No. of males	No. of females	No. of adults
From	To				
13th December 1926 .	30th December 1926 .	1	27	26	53
15th December 1926 .	10th January 1927 .	2	29	40	69
23rd December 1926 .	29th January 1927 .	3	45	56	101
23rd December 1926 .	31st January 1927 .	4	54	74	128
1st January 1927 . .	5th January 1927 .	5	..	5	5

The eggs are laid externally on the host and within 20 to 30 hours they hatch out and begin to feed on the paralysed caterpillar.

LARVAL AND PUPAL PERIOD

The larval period consists of 2 to 6 days. It takes 5 to 8 days for the adults to emerge from the pupae. The whole life-cycle thus covers from about 8 to 13 days.

TABLE XXXVIII

Period of total life-cycle of Microbracon lefroyi *during different months*

Months	No. of cases observed	Priod of life-cycle in days (Average)	Maximum period of life-cycle in that month
November 1926	18	10	11
December 1926	45	12	14
January 1927	76	13	16
February 1927	45	11	13
March 1927	53	9·5	10
April 1927	16	7·5	8

METHOD OF REARING THE PARASITES IN THE LABORATORY

A flat piece of glass, about 6 to 8 inches square was taken and a piece of blotting paper of similar size was placed on it. A round glass jar about 4 inches in diameter and about 5 inches in height was inverted and placed on this blotting paper. The adult parasites were liberated in the jars, and fully grown *Earias* larvae feeding in flower-buds, bolls or pieces of *bhendi* were inserted. A piece of blotting paper was placed on a small piece of glass (1 inch square) and the blotting paper was wetted with solution of sugar or honey. These pieces were placed inside the jars for providing food for the adult parasites. Fresh solution was offered twice or thrice a day. The host larvae along with their food were removed every day, and were placed in small sample tubes for recording the emergence of the parasites.

The food of the host larvae usually gave out a lot of moisture which used to accumulate on the sides of the glass cages. Calcium chloride in small sample tubes, closed with cotton wadding, was used for absorbing the moisture.

INCIDENCE OF *Microbracon lefroyi* AT SURAT

The Spotted Boll-worms begin to appear on the new cotton crop generally in August, and during September and October a large number of them are found feeding on the cotton shoots. *Microbracon lefroyi*, however, does not appear till flower-buds begin to develop, late in October or early in November. Thousands of shoots attacked by *Earias* larvae were examined but only one larva parasitised by *Microbracon lefroyi* was found in shoots. It appeared that the parasite was incapable of attacking the *Earias* larvae tunnelling into the cotton shoots. Larvae feeding in cotton shoots were offered to this parasite in the laboratory. The result was that it did parasitise the larvae feeding in tender shoots but not the ones which were feeding in comparatively harder internode. The probable explanation of the immunity of the *Earias* larvae feeding on the shoots in the cotton fields seems to be that it is only the younger larvae which feed on the tender parts of the shoots while the older ones, which are selected by the parasite for oviposition, generally penetrate the shoot by making a hole at a lower node where the shoot is very much harder.

These parasites increase in numbers after the month of October, and in December and January most of the larvae, in the cotton fields, which have reached the parasitisable stage, are found attacked. During 1928-29 a large number of *Earias* larvae were collected from the shed forms gathered from the cotton fields and the number of the caterpillars of the parasitisable age was recorded; as also the number of the larvae which were attacked by this parasite. It was seen that during the first fortnight of December, 66 per cent of the big larvae were parasitised by *Microbracon lefroyi*, whereas during the second fortnight of December this percentage increased to 90. In January the proportion of the fully grown larvae decreased very considerably, and the few big larvae which could be collected were all parasitised by *Microbracon lefroyi*.

TABLE XXXIX

Larvae parasitised by Microbracon lefroyi *out of the total larvae of the parasitisable size collected from shed forms in the cotton fields*

Period of observation	Total No. of larvae collected	Larvae big enough to be parasitised by *M. lefroyi*	Larvae actually parasitised by *M. lefroyi*	Percentage of the parasitised larvae out of the big ones
1st fortnight of December 1928 . . .	128	21	14	67
2nd fortnight of December 1928 . .	157	10	9	90
January 1929	178	5	5	100
February 1929	22	2	2	100

It is interesting to note that *Earias* larvae feeding in pieces of *bhendi* pods were freely parasitised by this wasp in the laboratory but the *Earias* larvae feeding on *bhendi* plants were never attacked by this parasite, even during November, December and January when the parasite was very common in the cotton fields. A large number of big larvae could thus be obtained from *bhendi* pods, at a time when they were very rare on cotton plants.

No explanation can be offered why this parasite, as well as *Actia aegyptia*, does not attack the *Earias* larvae feeding on *bhendi* plants. The fact, however, supports the conclusion that the cultivation of *bhendi* must be considered to be harmful to cotton, as it allows the rapid multiplication of this pest undisturbed by these two useful parasites.

In the cotton fields at Surat this parasite is present throughout the cotton-growing season except during the first two or three months, *viz.*, July, August and September.

Microbracon lefroyi D. AND G. IMPORTED FROM KHANDESH, PUNJAB AND KARNATAK.

It has been shown that *Microbracon lefroyi* appeared in the cotton fields at Surat in October or November. It was considered that if this parasite were present in the cotton fields a little earlier, or its numbers in October and November could be artificially increased by liberating a large number of parasites bred in the laboratory, the rapid increase of the *Earias* population on cotton in October and November could probably be effectively checked. It was known that this parasite appeared very much earlier in Khandesh and in the Punjab. It was decided to get specimens from these places and try to breed them at Surat.

Microbracon lefroyi FROM KHANDESH

A few of these parasites were brought from Khandesh in August 1925, for multiplication at Surat. They bred normally until October but refused to lay eggs afterwards. (Table XXXV.)

Live material was again secured from Khandesh in 1925, 1926 and in 1927. During 1925 and also in 1926, this was received at Surat in October and practically no eggs were laid after arrival. In 1927, the parasites were received in September and a few eggs were laid by them in that month. The adults from these eggs, however, turned out to be all males. Thus during all the four years the breeding of this parasite from Khandesh did not continue beyond October at Surat. These parasites did not interbreed with the local parasites or those from the Punjab.

Microbracon lefroyi FROM THE PUNJAB

Consignments of *Microbracon lefroyi* were received from the Punjab during August both in 1925 and 1926 through the courtesy of the Government Entomologist, Punjab. These parasites bred quite successfully in captivity at Surat. During both the seasons it was found that by April their oviposition declined very considerably, and the few eggs which were then laid all developed into males.

TABLE XL

Rearing of Microbracon lefroyi *from the Punjab at Surat during different months in 1925 and 1926*

Month of the emergence of the female	No. of pairs	Progeny.			No. of females which did not lay eggs	Remarks
		Males	Females	Total		
August 1926 .	1	20	7	27	1	The progeny is from only one pair received from the Punjab.
September 1926 .	9	75	31	106	6	
October 1926 .	26	463	155	618	2	
November 1926 .	42	654	120	774	27	From November onwards a large number of females and also males were taken out for various other experiments.
December 1926 .	15	120	45	165	6	
January 1927 .	10	140	32	172	5	
February 1927 .	17	127	56	183	6	
March 1927 .	5	18	5	23	6	
April 1927 .	1	3	..	3	2	

Microbracon lefroyi FROM KARNATAK

A few of these parasites were secured from Karnatak. They could also breed at Surat quite satisfactorily, but it was not possible to get them very early in the season as the cotton crop in Karnatak is sown even later than the crop at Surat.

It was observed that these parasites from the Punjab, Karnatak and Gujarat could interbreed without any difficulty.

Specimens of these parasites from all the localities, *viz.*, the Punjab, Khandesh, Gujarat and Karnatak were sent to Waterston for identification. He reported them all to be *Microbracon lefroyi* D. and G. Ramkrishna Iyer from Coimbatore, however, was of opinion that the Punjab ones might be slightly different, but there was no difference between the Surat and Khandesh ones. He attributed the apathy of the Khandesh ones to breed at Surat to different climatic conditions.

Microbracon REARED FROM OTHER SOURCES

A few specimens of Microbracon were reared from *Earias* larvae feeding on *Abutilon indicum* and from shoot rollers (*Phycita infusella* Meyr.) feeding on cotton shoots. A few more specimens were also collected from brinjal (*Solanum melangona*) on bud-worms (*Phthorimœa blaspsigona*). These were also sent to Waterston who identified them as under :—

Parasites reared from *Earias* larvae from *Abutilon indicum* were *Microbracon lefroyi* D. and G.

Parasites from *Phycita infusella* were *Microbracon brevicornis* and

Parasites from brinjal bud-worm were *Microbracon gelechediphagus.*

ATTEMPTS AT CONTINUOUS REARING OF LOCAL PARASITES

The trials of importing *Microbracon lefroyi* from distant localities showed that the parasites from Khandesh were not useful as they could not breed at Surat beyond October. In Karnatak they appeared very late so it was not possible to get the earliest supply of these parasites from that locality. It was possible to secure small consignments of *Microbracon lefroyi* from the Punjab, as early as August, and it was also found possible to breed them successfully at Surat. It was clear that large consignments of these parasites must be available to be able to liberate a very large number of them in the cotton fields in September or October. This was not, however, considered to be very practicable. An attempt was, therefore, made to find out if a large stock of the local *Microbracon lefroyi* could be carried from one season to another. Continuous rearing of the local *Microbracon lefroyi* was, therefore, arranged in the laboratory.

CONTINUOUS REARING OF LOCAL *Microbracon lefroyi* AT SURAT

A few pairs of these parasites were kept in separate jars for rearing. One of the difficulties which was experienced in this rearing was that after an interval

of a few days the proportion of males used to increase in the total progeny. A few trials showed that this was the result of breeding together of closely related parents, which naturally occurred under laboratory conditions of rearing.

TABLE XLI

Proportion of males and females in the progeny of parents closely related and of those which were not related.

—	Proportion of males to every 100 females in 1st generation.	Proportion of males to every 100 females in 2nd generation.	Proportion of males to every 100 females in 3rd generation.
Result of the breeding of closely related parents .	50	79	566
Result of the breeding of parents not related to one another.	50	58	32

MASS REARING

An attempt was made to devise suitable cages for mass rearing of these parasites. They were, however, not very successful.

Another method tried was the liberation of a large number of the caterpillars of the proper size on the cotton plants, enclosed in big muslin cages, along with the adult parasites. In one case 107 big *Earias* larvae were placed on four cotton plants bearing flower-buds and bolls in December 1926, and 20 females and a few males of *Microbracon lefroyi* were liberated inside A wooden trench with water and oil was kept all round to prevent the escape of the *Earias* larvae. A week later, it was found that seventy-three of these larvae were drowned in the trench, 17 were seen feeding on the plants, 8 pupated, one was found paralysed, and there was only one which was found attacked by the parasites. This method was repeated on two more occasions without any better results. The adults were found always sitting on the thin cloth, more anxious probably to gain their liberty than to oviposit under those conditions.

REARING AFTER MAY

The rearing of these parasites in separate rearing cages could be continued till the month of May. The oviposition by this time declined considerably and most of the eggs which were laid in this month developed into males. Besides this, at about this time the cotton crop was over, and difficulty of supplying host larvae to these parasites was badly felt. Pink Boll-worm (*Platyedra gossypiella* Saund) larvae which were found in the resting stage, and also a few caterpillars of *Jowar*

stem borer (*Chilo simplex*) which were found hibernating in *Jowar* stalks, were therefore offered. The parasites did lay their eggs on both kinds of caterpillars, but the larvae emerging from the eggs failed to develop on these hosts.

Carry-over of the pupae and the adults of *Microbracon lefroyi* in cold chambers

To see if the life of these parasites could be prolonged so as to get them to reach the next cotton season safely, a few pupae, which had passed 5, 7 and 9 days after pupation, were kept in the first four compartments at the cold end of the multiple temperature incubator (App. III), during February 1927.

Table XLII

Maximum period of pupation in the different compartments after the pupae were placed in them

(10 pupae in each compartment)

—	1st compartment temperature 48°F. to 54°F.	2nd compartment temperature 60° to 64°F.	3rd compartment temperature 64° to 68°F.	4th compartment temperature 70° to 76°F.
Maximum number of days for emergence from the five days old pupae.	33	11	9	3
No. of adults emerged from the above.	6	7	9	10
Maximum number of days for emergence from 7 days old pupae.	11	9	5	4
No. of adults emerged from the above.	6	9	7	6
Maximum number of days for emergence from 9 days old pupae.	13	3	emerged on the day they were kept.	
No. of adults emerged from the above.	8	9	10	10

The parasites emerging from these pupae could breed normally afterwards in the laboratory.

Similarly 18 adults (10 males and 8 females) were kept in each of the above four compartments for noting the total period of their life. They were fed with sugar solution every day.

TABLE XLIII

Length of life of adult Microbracon lefroyi *under continuous low temperatures of the first four compartments*

(See Table XLII)

——	First compartment	Second compartment	Third compartment	Fourth compartment
Maximum No. of days any of the adults lived.	More than 84	71	64	45
Minimum No. of days any of the adults lived.	30	25	3	2
Average life of the adults . .	44	38	31	14

Only six of these parasites lived for more than 84 days in the first compartment. These were then removed for observing the capacity of oviposition. It was, however, found that all of them died without laying any eggs. Besides this, 3 pairs of parasites were kept for egg laying in each of these four compartments All of them laid eggs except the ones kept in the first chamber where the temperature varied between 48° and 55°F.

These experiments showed that it was possible to prolong the life of the pupae as well as the adults considerably under low temperatures, but the procedure was impracticable under ordinary conditions; and besides there were indications that the adults which survived long enough would probably not breed normally.

An attempt was also made to keep the parasites alive in the pupal stage by keeping them at a very low temperature. A small cold chamber was, therefore, improvised by keeping a small round tin immersed in ice cold water continuously. The temperature inside this tin varied between 34 and 42°F. Forty Microbracon pupae were placed in this tin in a glass tube. Twenty of them were removed after 12 days and 4 adults emerged from this lot. The remaining 20 pupae were removed after 34 days and it was found that all of them were dead by that time. Thus it appeared that the pupae would not stand very low temperatures for a considerable length of time.

Finally, therefore, it must be admitted that after making a large number of efforts no easy and cheap method could be arrived at of securing a large stock of these parasites for making an attempt at augmenting the natural population of *Microbracon lefroyi* in the early part of the cotton-growing season.

Melcha nersei CAM. (PARASITE ON THE PUPAE OF *Earias*)

Out of the remaining four parasites, only *Melcha nersei* Cam. calls for comment.

Husain and Mathur [1923] have mentioned that these big parasites are seen flying about in the fields of cotton, lucerne, *senji* and in the gardens on hollyhocks in the Punjab. But they are not so commonly seen at Surat and it was only on a couple of occasions that their presence was noticed in the cotton fields. The marked absence of this parasite at Surat appears to be due to the fact that the *Earias* larvae invariably go to the soil for pupation in this tract and the pupae are not, therefore, exposed to the attack of this parasite. In the Punjab, on the other hand, a large number of *Earias* pupae are probably to be found on the parts of the cotton plants above the soil.

Only one female of this parasite was bred from a few pupae, collected from *bhendi* plants (*Hibiscus esculentus*) from Adajan, a small village near Surat, on 15th October 1924.

This female was kept in a glass rearing jar and *Earias* pupae were offered to it for oviposition. From the pupae, which were attacked, the first male emerged on the 31st of October and it was introduced in the cage of this female wasp. The female wasp escaped on 4th November 1924. During this interval we had offered a total of 176 *Earias* pupae, out of which 55 *Earias* moths emerged. Eight female and 37 male parasites emerged from the remaining 121 pupae.

A few of the off-spring of this parasite were kept under observation for recording the life-history during November and December at Surat.

Pair No. 1.— The female and male lived for 20 and 22 days respectively. During this period 168 *Earias* pupae were offered (ten fresh pupae were offered on most of the days). From these pupae 40 *Earias* moths and 12 female and 56 male parasites emerged. The period between the day on which the *Earias* pupae were attacked and the day on which the parasites emerged varied between 15 to 22 days.

Pair No. 2.— The female lived for 26 days and the male for 11 days. In all 222 *Earias* pupae were offered to the female. From these, 50 *Earias* moths and 82 male parasites emerged. The progeny consisted of males only, although a male parasite was present in the female cage for nearly 10 days and they were seen to mate. The period from egg to adult in this case varied between 15 to 24 days.

4. DETERRENTS

Attempts were made to find out if flowers of sulphur and cynogas dust (calcium cyanide) would be of any use as deterrents for the *Earias* moths.

A large number of cotton plants were dusted with flowers of sulphur mixed with road dust in the last week of December of 1923, and it was decided to keep

these plants under observation. After about 4 days, however, a very large number of flower-buds, young bolls and leaves were found to be dropping down from the dusted plants. The shedding continued for some time, and after a few days only a few stray leaves and developed bolls remained on these plants.

This experiment was repeated in the last week of February 1924, when a few plants of cotton were dusted with flowers of sulphur alone. This was also followed by shedding of forms, as in the above case.

Not only did the dusted plants suffer but heavy shedding of leaves, flower-buds and young bolls occurred on a large number of neighbouring plants over which the sulphur fumes were carried by wind.

These trials and subsequent experience of other workers [Thakar and Desai, 1929] showed that the plants of herbaceum cottons at Surat were extremely susceptible to the slightest traces of sulphur, and it was dangerous to expose the plants to any substance which was likely to give out even traces of free sulphur.

Cynogas dust (calcium cyanide A, supplied by Messrs. Shaw Wallace and Co., Bombay) was another substance which was tested for keeping the *Earias* moths from the cotton plants. During October 1926 the shoots of 200 plants were lightly dusted with this powder. The tender leaves of these plants were considerably scorched by it. An attempt was, therefore, made to spread a small quantity of this powder on the soil near stems of cotton plants, instead of applying it to them directly. Even this change did not prevent the scorching of the leaves, and hence the attempt to use this material as a deterrent was given up.

5. Attractants

It had been observed that a few *Earias* moths came to the lights in the residential quarters during January and February. It was found that ordinary Dietz lanterns as well as acetylene lamps exposed in the fields failed to attract any of these moths during the period of the heaviest infestation.

Aromatic substances such as, amyl acetate, methyl butyrate, acetic acid, formaldehyde, clove oil, molasses with yeast, vinegar, turpentine, rum, country liquor were exposed in the cotton fields. They were placed in small enamel dishes, which were kept in the centre of two feet square pans, containing water. None of these substances showed any attraction for these moths.

In the meanwhile we found that Power and Chestnut [1925] had determined the oderous constituents of cotton plants and had shown that ammonia and trimethylamine were present in appreciable quantities in the distillate obtained from these plants, and that they were also found in the emanations of the living cotton plants.

Ammonia, ammonium carbonate and rotting fish were, therefore, exposed, in bait pans. Rotting fish were used instead of trimethylamine as the smell of both the substances is said to resemble very closely. These substances also did not attract the *Earias* moths.

Attention was, therefore, diverted to find out if the cotton seeds, at any stage of their decomposition, would be able to attract the moths. A small quantity of seed was, therefore, moistened and was exposed in the same way as the substances mentioned above. The seed was again moistened at an interval of every 3 or 4 days. It was found that on some of the days a few moths of the Spotted Boll-worms could be found in the water pans. The attraction, however, was not constant and it appeared that very moist or very dry seeds were not effective in attracting the moths (App. I, Table XXVIII).

Bhendi (*Hibiscus esculentus*) seed was crushed and moistened and was similarly exposed in the cotton fields and the observations showed that it proved to be slightly superior to cotton seed (App. I, Table XXVIII).

It was not possible to say if it was the decomposition of the seeds of the host plants, which caused the attraction or if any similar substance would also be able to attract the moths. By analogy of the composition of these substances, therefore, moistened sesamum cake was exposed in the bait pans. The moths of the Spotted Boll-worms did respond to it, and it was found that the number of moths attracted to the cake pans, was more than that at the cotton or *bhendi* seeds. On the 31st of January 1928, as many as 38 moths were found round a single pan of sesamum cake, while in the pans of cotton and *bhendi* seeds there were only one and three moths respectively on that day (App. I, Table XXVIII).

The cakes of groundnut and cotton, in addition to that of sesamum, were tested and it was found that all three could attract a small number of *Earias* moths. Sufficient water was added to the powder of these cakes to form a paste before exposing them in the enamel dishes. Later on, however, it was found that these substances showed a better attraction when about 2 or 3 ounces of their powder was added directly to the bait pans containing about 2 or 3 gallons of water, instead of only moistening the cakes.

A few pans with these substances were exposed during most of the cotton growing season in 1929-30 and 1930-31, both at Surat and at Jalgaon in East Khandesh district (App. I, Tables XXIX to XXXII). The number of moths attracted to these pans at Jalgaon was considerably greater than at Surat.

It was rather peculiar that the largest number of moths were collected from these pans when the cotton crop was about to be over both at Surat and Jalgaon. Probably it meant that the attraction of these baits could only be strong enough to attract the moths in the absence of the vigorously growing crop of cotton, having tender shoots, flower-buds and young bolls.

It is interesting to note that these baits not only attracted the moths of the Spotted Boll-worms but also of the Pink Boll-worm (*Platyedra gossypiella* Saund.) and the shoot roller (*Phycita infusella* Meyr.). A very large number of Pink Boll-worm moths were attracted to these pans at Jalgaon (App. I, Tables XXXI and XXXII).

Paste of sandal wood and nutmeg, prepared by rubbing these substances on a rough stone with little water, also attracted a few moths of the Spotted and Pink Boll-worms.

The number of moths attracted to any of these substances was not sufficiently large to warrant the use of any of them as a control measure. The trials may, however, indicate possibilities of evolving a substance which may prove to be a powerful bait, not only for the Spotted Boll-worms, but also for the allied pests of cotton.

6. Soil mulch as a control measure

A careful search in the cotton fields at Surat showed that it was extremely rare to find a pupa of the Spotted Boll-worms on the plants This fact indicated that the larvae which are about to pupate, moved away from the cotton plants for spinning their cocoons. An examination of the soil, round the cotton plants showed that they were to be found in the soil, from about 2 to 8 inches below the surface of the soil.

It has already been mentioned that the fully fed larvae enter cracks and crevices for finding a suitable place for pupation Soon after the close of the monsoon the soil of the locality opens into small cracks, which slowly widen and have several sub-cracks, going in all directions from them. These cracks allow very easy access for the larvae to the soil and the pupae are often found in such small cracks, by the side of small clods (Plate I, Fig I). It has also been stated that the full-fed larvae descend the plants in the forenoon and immediately begin to search for a place for pupation. By about 2 p m., most of them are found to have begun the work of spinning their cocoons. This happens to be the hottest part of the day, and it is natural that the larvae should try to take shelter in the cooler layers of the soil.

The facts that the larvae almost invariably go to the soil for pupation in this tract, that they have to enter the soil through the existing cracks and crevices, that the moths, when they emerge have to make their way out of the soil through similar cracks and crevices, and that the larvae choose the hottest part of the day for selecting a place for pupation, all pointed out that this was likely to be a vulnerable point in the life of the Spotted Boll-worms.

What was required for successfully attacking the worms at this stage was to prevent them by some means from going deep in the soil, thus exposing them to the heat of the sun and to the attack of their predators ; or to prevent the emergence of the moths from the pupae in the soil. It was thought that this would be possible by maintaining a fine soil mulch in the cotton fields, and therefore trials were undertaken for testing the effect of soil mulch on the pupation and the emergence of moths of the Spotted Boll-worms.

The preliminary laboratory trials consisted of observing the emergence of moths from the pupae, which were covered over with a shallow layer of loose soil. Three wire gauge cages (one foot square) were taken and were filled in with field soil, which contained a few clods also. Twenty full-grown larvae were liberated in each one of them and they were allowed to pupate in the soil. The first cage was reserved as a control. In the other cages a layer of one inch and two inches of loose soil was added. The emergence of moths from these cages was noted and later the soil was examined to find out if any of the moths were caught in the loose soil.

TABLE XLIV

Emergence of the moths from the above three cages

(20 larvae liberated in each case)

Cage No.	No. of larvae pupated in the soil	Moths emerging above the soil	Moths dead in the soil	Percentage mortality
No. I, Control	19	19	*Nil*	*Nil.*
No. II, 1 inch layer of loose soil .	18	6	12	72
No. III, 2 inches layer of loose soil	13	*Nil*	13	100

All the moths in the first case came out normally; in the second case, however, 72 per cent of them could not extricate themselves from the loose soil and were stifled below the surface of the soil. In the third case all the moths died in the soil and were found with their wings crumpled up, when the soil was examined.

These trials only showed that if there is a small layer of loose soil over the pupae, most of the moths would fail to emerge. It was yet to be ascertained as to where the larvae would pupate, if a good soil mulch was maintained all over the cotton fields. Information on the following points was considered to be essential for determining the efficiency of the soil mulch as a control measure :—

(1) Will the larvae pupate on the surface of the soil if the area is mulched with fine soil ?

(2) Can they successfully pass all their pupation period in the above case and be able to emerge as moths normally ?

(3) Is the temperature of the surface layer of the soil high enough to kill the pupae ?

(4) Can the implements pulverise all the soil right up to the collar of the plants ? If not, what proportion of the larvae would pupate in the untreated space ?

A trial in the laboratory showed that when 20 full-grown larvae were liberated in a wire-gauge cage, containing pulverised soil (passed through a sieve with 16 meshes to a square inch) 17 of them pupated in the surface layer of the soil by binding together a few particles of the soil. Moths emerged normally from all these pupae.

This trial was later repeated in the fields, where 106 larvae were liberated in a small area (6 feet square) surrounded by a tin trench, containing water and oil. The temperature of the surface layer of the soil in the above space was found to be 108° F. at 2 P.M. on that day. Most of the larvae tried to escape from the enclosed space as they could not get a suitable place for pupation, and 58 of them were drowned in the trench in trying to go beyond. Later, when the soil was examined, no pupa could be traced and therefore it appeared that the remaining larvae must have been killed by the heat or were destroyed by their predators.

In another case 50 fresh pupae were scattered in the surface layer of an inch of the soil during the month of September. They were allowed to be there for a period of one week. An examination of the soil then gave a recovery of 31 cocoons out of the total of fifty. Fourteen of these were almost completely eaten up by predators, and 12 more were partially damaged. Only five pupae were found alive. Thus out of the fifty, only 31 could be secured and the remaining 19 were entirely missing. They were either devoured completely or were bodily removed by their enemies.

In the meanwhile, to study the effect of heat on the pupae, a few of them were subjected to different temperatures in the multiple temperature incubator (App. III). It was found that they could not stand a continuous temperature of more than 100°F., as all the pupae which were placed in the chambers with temperatures ranging above 100°F. failed to emerge as moths and were all found dried up.

Such continuous temperatures of about 100°F. or more are not naturally available in the fields. The soil temperature in the fields is the hottest between 12 noon and 4 P.M. Surface temperatures of the soil recorded at 12 noon, 2 P.M. and 4 P.M. once in a week, during October, November and December 1926, are given below for showing the range of temperature during the hottest part of the day.

TABLE XLV

Soil temperatures of the surface 1 inch layer in cotton fields

(Fahrenheit– 1926)

Date of recording	Mid-day	2 P.M.	4 P.M.
9th October	104	108	106
16th October	101	106	105
23rd October	105	112	108
30th October	105	111	109
6th November	100	106	103
13th November	109	110	109
20th November	103	112	106
27th November	100	108	103
4th December	101	114	112
11th December	100	111	108
18th December	100	109	102
25th December	100	109	105

These observations indicated that temperatures between 100° and 110°F. are available for a few hours during the day in October, November and December, in the surface layer of the field soil. The effect was then examined of exposing the pupae to about 110°F. for varying periods in the multiple temperature incubator. The emergence of moths from these pupae was noted.

TABLE XLVI

Emergence of moths from pupae exposed to 110°F.

No. of hours the pupae were exposed	Number of pupae under observation	No. of moths emerged
4	10	9
8	10	7
24	10	5
48	10	*Nil* } All dried up.
72	10	*Nil* }

A few of the pupae could endure the temperature of 110°F. for about 24 hours, but all those which were kept at that temperature for 48 hours or more, were shrivelled up and dead due to the heat.

Attempts were next made to find out if it would be practicable to secure the desired soil-mulch with different implements. The blade harrow was found to be the best implement for pulverising the soil when it was used in the optimum condition of the soil. All the implements, however, left a small space of a few inches undisturbed near the collar of the plants. It was clear that some of the larvae would take advantage of this unmulched area for pupation. Further trials of artificially liberating the larvae in the fields showed that when a space of about 6 inches round each plant was left untreated, 20 per cent of the larvae (16 out of 80) pupated in this space. When this space was reduced to 2 inches, 10 per cent (10 out of 102) of the larvae pupated in that small space.

The last few trials indicated that the presence of well pulverised soil in the fields would prevent the larvae from going below the surface layers if the soil could be mulched right up to the collar of the plants and that some of these, which would pupate in the surface layer, would be destroyed by the heat of the sun or by the predators.

In order, therefore, to get a definite idea about the efficiency of the soil-mulch as a control measure, it was decided to lay out small plots with and without mulch, and to observe the natural pupation under those conditions.

Four plots of cotton, about 4 or 5 *gunthas* each, were selected at the commencement of the cotton-growing season during 1928-29. One of these plots received all the usual tillage operations as in the case of the whole cotton field, and was reserved as a control. All the soil in the second plot was carefully pulverised, and fine soil-mulch was maintained in this plot throughout the season by stirring the soil repeatedly, and by breaking the clods which came up. Similar soil-mulch was maintained in the third plot, but a space of about 4 inches round each plant was left untreated in that plot. No cultural treatment was given to the fourth plot and the soil was allowed to crack to the maximum extent. The soil around 9 plants (plants spaced 4′×3′) was carefully examined in each one of these plots, once a month, for pupae of the Spotted Boll-worms (Tables XLVII to XLIX).

During the next season, 1929-30, only 3 plots were laid out :-

1st plot.—Control. Normal tillage.

2nd plot.—With good soil mulch, except 4″ round each plant.

3rd plot.—With clods. The clods were purposely turned up and were not pulverised in order to have a very good contrast with the plot having well pulverised soil.

Soil round 20 plants (spaced 4′×3′) was examined once in a month from each one of these plots.

The plot with the soil-mulch going right up to the collar of the plants was not attempted as it was found impracticable to pulverise the soil with any implement without leaving at least some space untreated round the plants.

The soil was removed for observation by separating out small clods and these were carefully examined. The positions of the pupae found in the soil were recorded. The loose soil was again passed through sieves to prevent the loss of any of the pupae through oversight.

TABLE XLVII

Depth at which the cocoons were found in the soil

Depth in inches	1928-29				1929-30		
	Control plot	Plot with cracks	Plot fully mulched leaving 4″ round plants	Plot fully mulched	Control plot	Plot with clods and cracks	Plot fully mulched except 4″ round plants
1	14	14	18	35	13	3	10
2	5	8	6	5	9	10	8
3	2	2	..	2	7	23	9
4	1	2	..	1	..	12	2
5	1	2	..	..	..	5	..
6	1	1	1	..	4	3	5
7	1	3	2	..	5	..	8
8	..	1	1	..	..	1	..
9	..	1	1	..	2	1	1
10	1	1	..	..	..	1	..
11	..	..	..	..	1	1	..
12	..	1	..	..	..	..	..
13	..	2	..	..	..	..	..
Cocoons caught in the sieve.	1	..	2	2	4	3	5
TOTAL .	27	40	31	45	45	63	43

TABLE XLVIII

Proportion of the cocoons in the surface one-inch layer of the soil.

Plots	Total cocoons	Cocoons in 1st 1-inch layer	Percentage of the cocoons in surface 1-inch layer
1928-29.			
Control	26	14	54
With cracks	40	14	35
Mulched leaving 4" round plants	29	18	62
Fully mulched	43	35	81
1929-30.			
Control	41	13	32
With cracks and clods	60	3	5
With mulch leaving 4" round plants	38	10	26

The cocoons which were found in these plots were examined and were placed in three classes :—

(1) Live pupae.
(2) Damaged cocoons (destroyed by predators).
(3) Empty cocoons, which showed that moths had emerged out normally from them.

TABLE XLVIX

Plots	Total cocoons	Live pupae.	Dead or damaged cocoons	Percentage damaged cocoons	Empty cocoons showing normal emergence	Percentage empty cocoons
1928-29.						
Control plot	27	5	4	14·8	18	66·6
Plot with cracks	40	8	10	25 0	22	55·0
Plot mulched leaving 4" round plants.	31	4	11	35·5	16	51·6
Fully mulched plot	45	11	15	33·3	19	42·2
1929-30.						
Control plot	45	2	17	37·8	26	57·8
Plot with cracks and clods	63	5	22	34·9	36	57·1
Plot mulched leaving 4" round plants.	43	5	20	46·5	18	41·9

It was found that the surface of one-inch layer of the mulched plots had comparatively a larger number of cocoons than those which were found in similar layers of the other plots, having cracks and clods. But it was also true that in these plots, some of the cocoons were found in the deeper layers also, in spite of the surface soil-mulch.

Secondly, it was observed that the mulched plots had a larger proportion of damaged cocoons and that in these plots a smaller number of them showed signs of normal emergence, as compared with the other plots. The difference, however, was not substantial and it appeared that moths did emerge successfully from the mulched plots also.

Thus it was found that the pupation in the mulched plots was not restricted only to the thin surface layer of the pulverised soil, and that it appeared that a good number of moths could emerge normally from cocoons in these plots. This was mostly due to the following reasons.

A large number of cracks began to appear in the mulched plots as the soil began to dry up. It was, therefore, necessary to stir the soil very often in the mulched plots for preventing the cracks. In stirring the soil, the fine particles of the soil settled down deeper and small clods came up to the surface. After the surface soil had dried up, it was impossible to pulverise these clods and therefore they provided very good shelter for the pupae in these plots.

It was also found that some of the pupae in the soil were destroyed by predators, such as lizards, which lived in the cracks. They could not, however, be active in the mulched plots in the absence of cracks.

All these observations, therefore, showed that soil mulch, as far as it can be maintained in the field conditions at Surat, could not be considered to be an effective control measure against the Spotted Boll-worms, though the preliminary trials indicated possibilities of its success.

7. Insecticides

Stomach poisons are generally recommended for insects which have a biting habit of feeding. The possibility of this kind of insecticide being effective against the Spotted Boll-worms was doubtful, because they bore into their food and then continued feeding from inside the food. The only chance, therefore, of their getting the poison is while making an entrance hole.

A few preliminary trials in the laboratory, however, indicated that a very high mortality ensued when these worms were fed on flower-buds and bolls which were previously sprayed or dusted with lead arsenate or Paris Green.

TABLE L

Mortality of larvae fed on flower-buds sprayed with lead arsenate and Paris Green

Poison	No. of worms fed	Mortality on each day after feeding							TOTAL
		1	2	3	4	5	6	7	
Lead arsenate 2 ozs. to 4 gallons of water.	100	28	22	28	10	..	11	..	99 dead and 1 pupated.
Paris Green ½ oz. to 4 gallons of water.	100	54	24	16	6	..	..	..	100

TABLE LI

Mortality of larvae fed on flower-buds dusted with lead arsenate and Paris Green

Poison	No. of worms fed	Maximum number of days for which any of these larvae lived	No. of larvae pupated	Percentage mortality
Lead arsenate dust . . .	50	16	6	88
Paris Green dust . . .	50	14	12	76
Untreated	50	..	32	36

Experiments in the fields were, therefore, undertaken in plots of about half a *guntha* each, for testing the practical efficiency of these insecticides. Both sprayings and dustings were attempted at the interval of one, two and three weeks. The treatments were restricted to the months of November and December and a part of January when the boll-worms were particularly active on the cotton plants. Lead arsenate was sprayed at the rate of 2 ounces for 4 gallons of water and Paris Green at half an ounce to 4 gallons of water. Lead arsenate and Paris Green were

mixed with powdered lime in the proportion of 1 to 8 before dusting. The results of these treatments are tabulated below :—

TABLE LII

Cotton plants sprayed and dusted with lead arsenate and Paris Green.

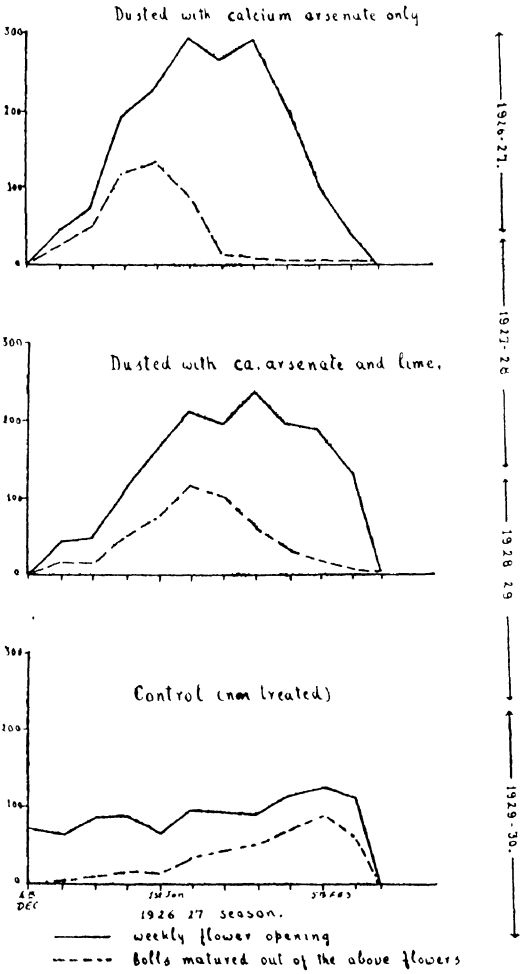
1924-25

Treatment	Plants under observation	Flowers per plant	Mature bolls per plant	Percentage flowers to bolls	*Kapas* per plant in Tolas
Check plot	54	86	40	46	7·1
Lead arsenate sprayed once in a week .	54	71	31	43	5·0
Lead arsenate sprayed once in two weeks	52	67	33	49	5·5
Lead arsenate sprayed once in three weeks	54	71	33	46	5·5
Lead arsenate dusted once in a week .	51	82	37	44	6·1
Lead arsenate dusted once in two weeks .	53	75	36	48	5·9
Lead arsenate dusted once in three weeks	54	82	37	45	6·2
Paris Green sprayed once in two weeks .	54	64	28	43	4·1
Paris Green dusted once in two weeks .	53	72	31	42	4·7

These trials showed that no advantage could be seen as a result of these treatments at any stage of the plant growth or in the final yields of *kapas*. Paris Green was, on the contrary, found to be harmful as it affected the leaves, to a certain extent, and ultimately reduced the number of bolls and the yield of *kapas*.

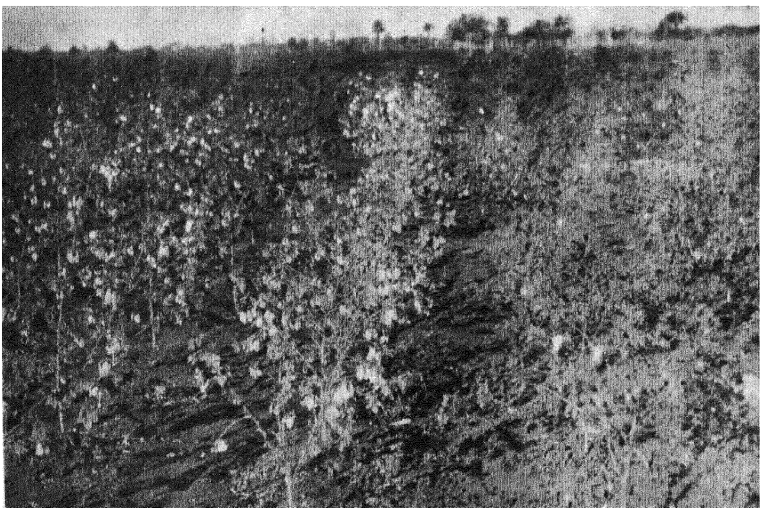
In the meanwhile, it was observed that the tiny *Earias* larvae as soon as they come out of the eggs have the habit of wandering about on the plant for some time before they begin to feed. It was considered that these larvae would get the poison very easily if the plants were dusted with a very finely powdered insecticide. It was, therefore, decided to try calcium arsenate which was being extensively used against the boll-weevil (*Anthonomus grandis*) in America. During 1926-27, therefore, three plots of 100 plants each, were laid out for these trials. One of these was dusted with calcium arsenate without any dilution ; and in the other, a mixture of calcium arsenate and slaked lime was used in the proportion of 1 to 3. The third plot was reserved as a control. These dustings were started in the last week of November and were repeated at the interval of 5 days till the end of December.

The beneficial results of these applications were soon apparent. The dusted plots showed a number of developed flower-buds within a few days, and the vigorous flower formation reached its height 5 weeks earlier than in the control plot. (Plate XII.) This indicated that the earlier flower-buds in dusted plots had escaped the



Showing periodical flower opening and relative success of bolls from dusted and undusted plants at Surat during 1926-27

PLATE XIII.



Early opening of bolls in plot (left) dusted with calcium arsenate.

damage of the boll-worms and had succeeded into flowers in large proportions (Appendix I, Table XXXIII). It was also found that the earlier flowers were retained on these plants in larger proportions than on the control plants. Consequently a large number of bolls opened on the dusted plants very much earlier than the general field plants. (Plate XIII.)

In order to obtain comparative data upon the number of worms in the dusted and the control plots, 25 plants were examined from each of the 3 plots, 4 weeks after the dustings were started. The results of these examinations are summarised in the next two tables.

TABLE LIII

Examination of 25 cotton plants in each case

Treatment	Total flower-buds	Total bolls	Live larvae	Dead larvae (very tiny)	Live eggs
Calcium arsenate	2,992	139	60	463	596
Calcium arsenate and lime . . .	2,935	128	117	97	205
Control	2,116	*nil*	123	*nil*	28

TABLE LIV

The number of bolls and the proportion of the flower-buds of different sizes from the above plants

Treatment	Smallest buds	Small buds	Medium buds	Big buds	Bolls
Calcium arsenate	1,364	651	597	205	139
Calcium arsenate and lime . . .	1,845	646	338	106	128
Control	1,711	244	112	25	*nil*

The following points are noticeable in the above tables :—

(1) The plants from the dusted plots had a few bolls on them at a time when the non-dusted plants had none. Besides they carried a large number of big sized flower-buds.

(2) Dusted plants had a smaller number of live boll-worm larvae than the control plants.

(3) A very large number of tiny dead larvae could be seen all over the dusted plants.

(4) The dusted plants had an unexpectedly high number of live eggs of the Spotted Boll-worms.

It must be noted that the above facts were more markedly seen in the plot dusted with calcium arsenate only than in the other which was dusted with calcium arsenate diluted with slaked lime.

The conclusions which these facts could warrant were that the calcium arsenate was successful in killing a large number of boll-worm larvae, and most of them were killed, just after they had emerged out of their eggs and before they got into their food. This further indicated that the larvae got a dose of the poison while crawling in search of their food on the parts of the plants, which were covered with the dust. It was the large mortality of these larvae which allowed the appearance of better developed flower-buds and bolls, earlier in the dusted plots. The presence of these advanced forms on the dusted plants, in larger numbers than what were to be found anywhere in the surrounding cotton plots, appeared to have attracted a very large number of moths to oviposit on them, with the result that the number of live eggs on the dusted plants swelled to an unexpected extent. This was a very significant fact, because it emphatically pointed out that in spite of the continuous abnormal oviposition, the dust could afford protection to the flower-buds and bolls by keeping the larval population very low. It would probably have been still lower if the oviposition had continued to be normal.

The treatment appeared to be very hopeful, and to promise a large increase in the yield of *kapas*. However, with the commencement of vigorous flowering, a heavy infestation of aphis (*Aphis gossypii*) developed on the dusted plants, and they were soon covered by the sugary secretions of this pest. As a result of this trouble the dusted plants finally did not even yield the normal number of bolls, found on the control plants.

TABLE LV

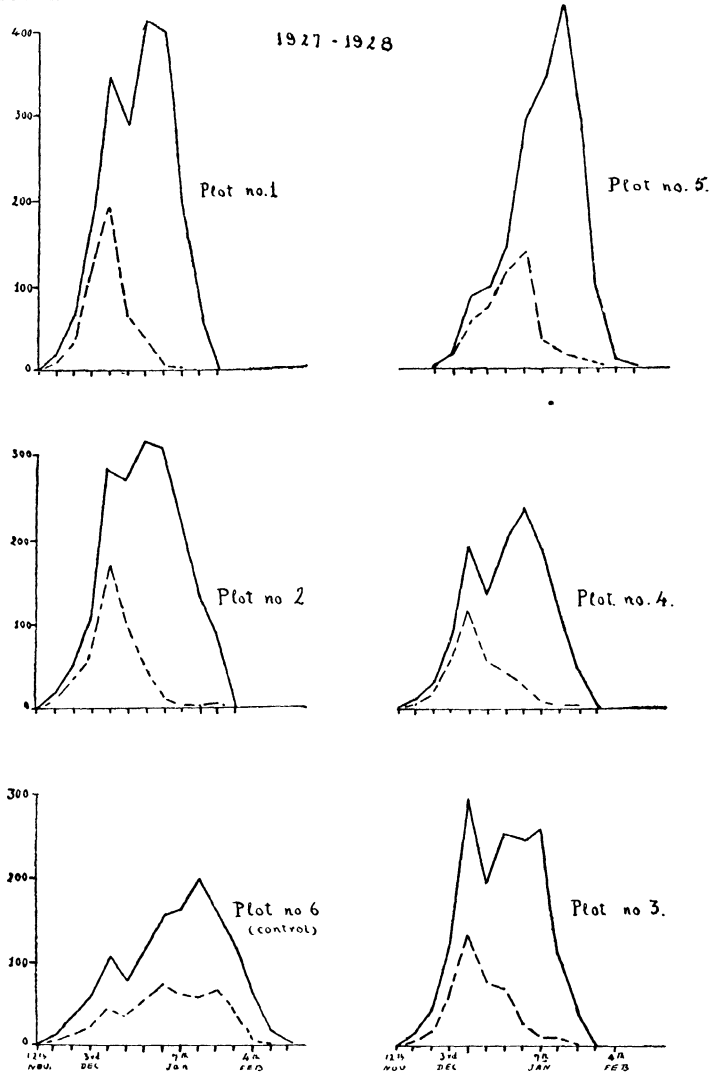
Dusted and control plants

1926-27

(Average of 20 plants in each case)

Treatment	Total flowers per plant	Total mature bolls per plant
Calcium arsenate	87	24
Calcium arsenate and lime	76	25
Control	82	31

PLATE XIV.



Showing weekly flower-opening and relative success of bolls in cotton plots dusted and undusted with insecticides.

A few more trials were again laid out during the next season (1927-28) to find out, if the aphis infection would recur during every season, and if it would be possible to escape it by some means. The following were some of the treatments which were attempted. They were carried out during the period from the middle of October to the middle of December, which generally happens to be the period of heavy boll-worm damage—

(1) Dusting with calcium arsenate at the interval of 5 days, from the end of October till the middle of December.

(2) Dusting as above and 4 sprayings with fish-oil rosin soap, after the appearance of aphis.

(3) Dusting with calcium arsenate at intervals of 10 days, from the middle of October till the middle of December.

(4) Two dustings of calcium arsenate at the commencement of the flower-bud development for protecting the flower-buds, and two more at the flowering period for securing success from the earliest flowers.

(5) Only two dustings of calcium arsenate at the period of flowering.

(6) Dustings with calcium arsenate diluted with gram flour (in the proportion of 1 of calcium arsenate to 2 of flour) at intervals of 5 days from the end of October till the middle of December.

About 100 plants were treated in each case and 20 plants were selected in the middle of each of the plots for noting the daily flower opening, boll shedding and the final number of mature bolls. These results have been included in Appendix I, Table XXXIV (Plate XIV). Some of the important points seen from these figures are enumerated below :—

(1) Intense flowering was much earlier in the dusted plots than in the control ones.

(2) The plots dusted with calcium arsenate at 5 and 10 days intervals respectively had about the same period of flowering but the intensity of flowering in the plot dusted at intervals of 10 days was lower.

(3) The plot, which received calcium arsenate diluted with gram flour, did not show as much intensity of flowering as the one which received arsenate alone.

(4) The plot which was dusted with calcium arsenate at intervals of 5 days and was also sprayed with fish-oil rosin soap (against aphis) showed an advantage over the similarly dusted plot, which was not sprayed. It retained proportionately a larger number of flowers, during the weeks which followed the sprayings.

(5) The plot which was dusted twice only with calcium arsenate showed a remarkable rise in flowering immediately after the commencement of

dustings; and the early flowers gave a higher percentage of success of flowers to bolls than the untreated plots.

These trials, therefore, again pointed out that as a result of the dustings of calcium arsenate, an intense early flowering took place and the early flowers were retained on the plants in larger proportions.

Soon after the commencement of the flowering it was, however, found that during this season also infestation by aphis began to appear, and it was found to be very serious in the dusted plots during December. This affected very considerably the production of *kapas* in the dusted plots as can be seen from the next table. Yields of *kapas* from 8 untreated plots (with about 100 plants in each) selected at random, in the same field, are also shown for judging the normal variation of yield in that field.

TABLE LVI

Treatments	No. of plants observed	Total yield of *kapas* in tolas
1. Dusting calcium arsenate every 5 days	99	263
2. Dusting calcium arsenate every 5 days and spraying with fish-oil rosin soap.	98	310
3. Dusting calcium arsenate with gram flour	101	270
4. Dusting calcium arsenate twice at flower-bud development and twice at flower-opening period.	99	209
5. Dusting calcium arsenate at every 10 days	95	236
6. Dusting calcium arsenate twice only	93	258
7. Untreated plot	99	540
8. Do.	99	531
9. Do.	98	410
10. Do.	100	497
11. Do.	100	488
12. Do.	100	517
13. Do.	99	425
14. Do.	99	343

The yield of *kapas* in all the dusted plots was markedly reduced in spite of the early intense flowering and the better retention of the earliest bolls in these plots. This effect was mainly due to the serious aphis infestation. No foliage injury was noticed on the plants dusted with calcium arsenate. It is significant to note that of all the dusted plots, the one in which the aphis infestation was partially controlled by using fish-oil rosin soap, yielded the largest amount of *kapas*.

It appeared that it would be necessary to give up the pursuit of this insecticide because it was found that its use on the cotton plants was always followed by severe aphis infestation which obliterated its beneficial effect. In the meanwhile, however, W. J. Folsom [1927] pointed out that the heavy infestation of aphis in small experimental plots dusted repeatedly with calcium arsenate was the result of the positive photo-tropic response of the winged aphis to the white dust, and of the immunity which they got from some of their enemies in the presence of this insecticide. He summarised his experience in the following words :—

" Excessive applications of calcium arsenate are often followed by heavy infestations of the cotton aphis. The initial infestations are due to the positive phototropic reaction of winged females to white substances, such as, calcium arsenate, calcium carbonate, starch or flour. A heavy infestation is built up, not by the destruction of predators by calcium arsenate, but by the killing of hymenopterous parasites when they emerge in the presence of the arsenical. They are killed also, though more slowly, by calcium hydroxide, calcium carbonate, corn and starch."

It was, therefore, decided that the white powder of the insecticide should be blackened with finely-powdered charcoal in order to find out if the aphis infestation could be prevented.

It was also decided to lay out a few trials for testing another insecticide, *viz.*, sodium silico-fluoride, along with calcium arsenate during 1928-29 ; because Osborne [1926] had found that sodium fluosilicate was more toxic to the cotton boll-weevil than calcium arsenate.

The plants could not be dusted uniformly with the Vermorel Knapsack dusting machine used so far, and therefore, a new machine called " The Peerless Dusting gun " was purchased.

The calcium arsenate previously used contained more than ·75 per cent soluble arsenic acid, which was undesirable according to Coad and Cassidy [1920], and a fresh stock of calcium arsenate was secured from Grasselli Chemical Co. of New York, U. S. A. (for analysis see Appendix I, Table XXXV). A stock of sodium silico-fluoride was also secured from the same firm.

It was further realised that it would not be possible to protect the cotton plants from the Spotted Boll-worms during all the period of three or four months of the activities of the pest. It was, therefore, necessary to ascertain the stage of plant

growth, at which the use of the insecticides would be most beneficial upon the yield of *kapas*. The period of plant growth was divided into three parts as under :—

(1) Early part of the season, when most of the *Earias* population is concentrated on the shoots of cotton.

(2) Period when the flower-bud development is most vigorous.

(3) Period when the flower-opening is at its height.

In order, therefore, to determine the most suitable period for using the insecticides and in order to find out if the aphis infestation could be prevented by blackening the insecticides, the following trials were laid out during 1928-29 :—

Plot No. 1.—Dusting with blackened calcium arsenate when the Spotted Boll-worms are feeding on cotton shoots.

Plot No. 2.—Dusting with blackened calcium arsenate when vigorous flower-bud development is in progress.

Plot No. 3.—Dusting with blackened calcium arsenate when the boll-development has commenced.

Plot No. 4.—Dusting with calcium arsenate when vigorous flower-bud development is in progress.

Plot No. 5.—Dusting with sodium silico-fluoride when flower-bud development is in progress.

Plot No. 6.—Dusting with blackened sodium silico-fluoride when flower-bud development is in progress.

Blackened calcium arsenate was prepared by mixing calcium arsenate and finely-powdered charcoal in equal proportions. Sodium silico-fluoride, is a heavier salt and therefore, one part of finely-powdered charcoal was mixed with two parts of this insecticide.

Each of the plots consisted of 100 plants, and in each case an adjoining plot with about the same number of plants was kept as a control.

The actual dates of dusting are given in Table XXXVI of Appendix I.

Foliage injury.—Showers of rain after dusting with sodium silico-fluoride were harmful to the foliage. The leaves developed brownish red spots but did not shed. They were seen on these plants until the bolls began to open. Some of the flower-buds, however, dropped away from these plants. There was no such injury noticed in the plots where calcium arsenate was used.

Insecticides and Spotted Boll-worms.—Examination of plants for *Earias* larvae from the dusted and the control plots showed that sodium silico-fluoride was distinctly more effective in reducing the *Earias* population in the plots where that insecticide was used.

TABLE LVII

Population of Earias *larvae on dusted and control plants*

1928-29

Date of examination	Plot No.	No. of plants examined	No. of flower-buds	No. of bolls	Live *Earias* larvae	Dead *Earias* larvae
13th November 1928 . .	4	10	1,157	12	1	7
14th November 1928 . .	2	10	1,193	17	17	14
15th November 1928 . .	5	10	1,247	30	1	7
16th November 1928 . .	6	10	1,250	30	6	6
16th November 1928 . .	Control (Non-treated).	10	1,098	29	33	..
1st December 1928 . .	2	10	1,442	191	45	30
3rd December 1928 . .	4	10	1,905	340	37	49
5th December 1928 . .	5	10	596	227	..	15
6th December 1928 . .	6	10	747	246	2	9
6th December 1928 . .	Control	10	1,333	108	38	..

For the above examinations ten plants were up-rooted from each one of the above plots, once during the middle of November 1928, eight days after the commencement of the dusting in the respective plots and a second round of samples of ten plants from each plot was taken in the first week of December 1928, *i.e.*, nine days after the 3rd application of the insecticide in each plot.

APHIS INFESTATION

In order to estimate the comparative infestation of this pest under different treatments, twenty cotton leaves were collected at random once in a week from plot Nos. 2, 4, 5 and 6 and also from a control plot. The aphis on these leaves were counted as accurately as possible.

TABLE LVIII

Population of aphis on 20 leaves from cotton plots dusted with white and blackened powders of insecticides

1928-29

Plot No.	Treatment	No. of aphis on 20 leaves							
		8th Dec.	15th Dec.	22nd Dec.	29th Dec.	5th Jan.	12th Jan.	19th Jan.	26th Jan.
2	Blackened calcium arsenate at bud-development.	traces	7	147	110	274	252	575	772
4	White calcium arsenate at bud-development.	,,	155	188	499	948	820	1,006	1,767
5	White sodium silico-fluoride at bud-development.	,,	289	361	561	617	882	1,182	1,673
6	Blackened sodium silico-fluoride at bud-development.	—	—	13	28	106	104	78	270
	Control (Not dusted) . .	—	1	66	17	56	37	7	48

All the plots were sprayed once with fish-oil rosin soap on 9th January.

A small amount of aphis infestation was present on the general cotton crop from the middle of December till the end of January. This probably served as a nucleus for the higher infestation which was built up in the plots dusted with blackened calcium arsenate and sodium silico-fluoride. Out of these two plots the plants dusted with blackened sodium silico-fluoride showed a much less infestation, probably because this mixture was slightly darker in colour than the powder of blackened calcium arsenate. The plants dusted with white calcium arsenate and sodium silico-fluoride suffered from a very serious aphis infestation, because they must have attracted winged aphis from the general cotton area in addition to the traces of original infestation which existed on them. These trials, therefore, showed that blackening the insecticide would not altogether prevent the aphis infestation, but that it would not be as serious as on the plants dusted with white calcium arsenate or sodium silico-fluoride.

BOLL-DEVELOPMENT AND YIELD OF *kapas*

Twenty plants in each of the treated plots and their controls were reserved for studying the effect of the treatments on the flower opening and the development of bolls. The weekly flower opening and the relative number of bolls which matured is given in Appendix I, Table XXXVII. Besides this, the number of mature bolls

from all the plants from the plots were counted, and the *kapas* from each of the plants was collected and weighed separately. The average yield of bolls and *kapas* from these plants is given below.

TABLE LIX

Number of bolls and yield of kapas *from the dusted plots and their controls*

1928-29

Plot No.	Treatment	Number of plants observed	Number of bolls per plant	Weight of *kapas* per plant in grms.	Percentage increase or decrease of *kapas* per plant over the control
1	Blackened calcium arsenate at shoot attack	100	28·3	47·7	—21·1
1-A	Control for plot No. 1	100	24·7	60·5	
2	Blackened calcium arsenate at flower-bud development.	100	28·2	55·2	8·6
2-A	Control for plot No. 2	99	27·8	50 8	
3	Blackened calcium arsenate at boll-development.	100	35·8	66·3	14·9
3-A	Control for plot No. 3	100	30·6	57·7	
4	White calcium arsenate at flower-bud development.	100	40·3	64·2	1·5
4-A	Control for plot No. 4	100	35·5	63·2	
5	White sodium silico-fluoride at flower-bud development.	100	25 4	43·5	—43·2
5-A	Control for plot No. 5	99	41·1	76·6	
6	Blackened sodium silico-fluoride at flower-bud development.	100	32·5	60·4	12·3
6-A	Control for plot No. 6	100	29·0	53·8	

All the plots, where the plants were dusted with blackened insecticides yielded more *kapas* than their controls except plot No. 1 and plot No. 5.

Plot No. 1 received three dustings with blackened calcium arsenate on 8th, 18th and 29th October 1928. These plants were not dusted afterwards As a result of these dust ngs, these plants began to flower vigorously early in November (Appendix I, Table XXXVIII); but the application of the insecticide to these plants had already stopped, and therefore, the big flower-buds and the young bolls

shed in large numbers due to the damage of the Spotted Boll-worms (Plate XV). It was, therefore, found that the use of the insecticides during the early part of the season would not be practicable because the dustings could not be continued till about the end of December when the Spotted Boll-worms normally declined, and if they were discontinued earlier, all the advantage gained by the early dustings would be lost, because the Spotted Boll-worms would concentrate in these advanced plots and would damage the developed forms. It might, therefore, be stated, in general, that the use of insecticides like calcium arsenate and sodium silico-fluoride during the early part of the plant growth would be distinctly harmful under Surat conditions.

The plot of blackened calcium arsenate at boll-development yielded more *kapas* than the plot which received the same insecticide at the time of flower-bud development.

White sodium silico-fluoride at the time of flower-bud development turned out to be distinctly harmful, but gave 12·3 per cent more *kapas* when it was blackened before use.

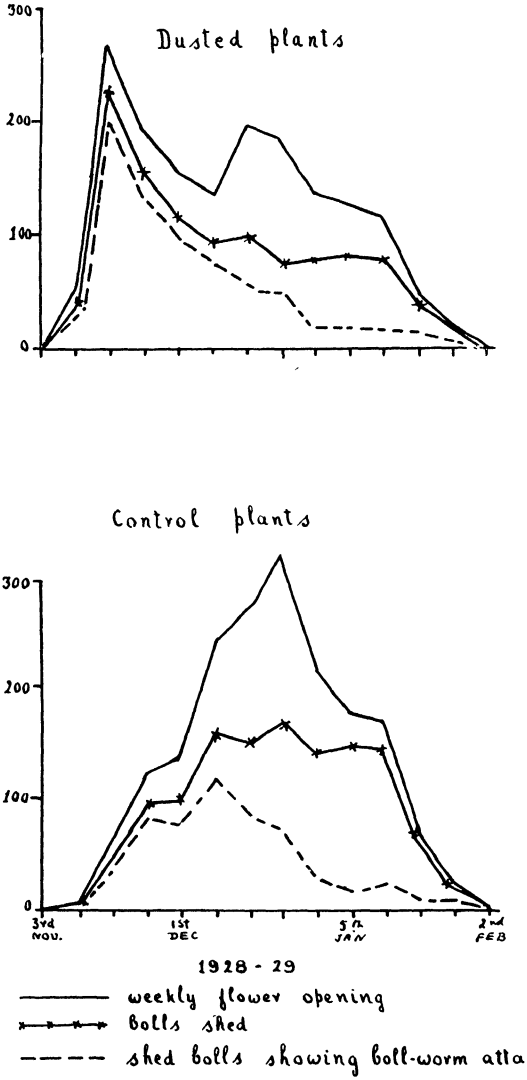
The plants, dusted with white calcium arsenate at flower-bud development, yielded nearly five bolls more than the control plants, but they could hardly yield two per cent additional *kapas*. This was apparently due to the fact that the bolls on these plants did not develop normally due to excessive aphis infestation during the period of their development.

Slaked lime and aphis infestation

Powder of slaked lime is quite as white as the powder of calcium arsenate. A test was made to see if the use of slaked lime alone would lead to serious aphis infestation. During the course of the above trials, two groups of twenty plants each were selected, and one was dusted with calcium arsenate and the other with slaked lime. After an interval of about ten days both the groups showed the commencement of aphis attack, but the plants dusted with lime had comparative'y very few aphis on them. Within another ten days, the plants with calcium arsenate were seriously infested with aphis, whereas, their increase on the plants dusted with lime was very slow. It was, therefore, clear that calcium arsenate afforded very much better conditions for the multiplication of aphis.

Trials during 1929-30

In the light of the experience of the previous season, it was decided that the use of the insecticides should be concentrated during the boll-development period only.



Showing weekly flower-opening, shedding of bolls and bolls shed due to boll-worms in a cotton plot dusted with calcium arsenate during the period of shoot attack; and also in the control plot.

It appeared that during the previous trials excessive quantities of insecticides were applied, and hence it was decided to regulate the doses.

Nicotine sulphate (" Black leaf 40 ") was also to be used for attempting the control of aphis.

The following trials were, therefore, laid out :—

Plot No. 1.—A cotton plot of one acre to be dusted with blackened calcium arsenate at the rate of 20 lbs. of mixture per acre. Nicotine sulphate to be used when aphis appear.

Plot No. 2.—One hundred plants to be dusted with blackened calcium arsenate at the rate of 20 lbs. of mixture per acre.

Plot No. 3.—One hundred plants to be dusted with white calcium arsenate at 20 lbs. to an acre and nicotine sulphate to be used when aphis appear.

Plot No. 4.—One hundred plants to be dusted with white calcium arsenate at 10 lbs. per acre.

Plot No. 5.—One hundred plants to be dusted with blackened sodium silico-fluoride at 40 lbs. of mixture per acre.

Plot No. 6.—One hundred plants to be dusted with blackened sodium silico-fluoride at 40 lbs. of mixture per acre and nicotine sulphate to be used for controlling the aphis.

Plot No. 7.—One hundred plants to be dusted with white sodium silico-fluoride at 20 lbs. per acre. Details of the dates of dustings, the quantities of insecticide actually used and their cost calculated per acre are given in Appendix I, Table XXXIX.

Aphis infestation during 1929-30

Traces of aphis were noticed during this season also from the month of December onwards on the general crop of cotton. On the dusted plots they began to increase rapidly within four weeks after the commencement of the dustings.

Small plots of about 100 plants, when they were dusted with calcium arsenate or sodium silico-fluoride, developed a serious infestation of aphis. An area of one acre of cotton (Plot No. 1) was taken for dusting with blackened calcium arsenate in order to observe the effect upon a very much larger area when under this treatment. Aphis infestation turned out to be the worst in this plot, and could not be checked even with two applications of nicotine sulphate (Table LX).

In plots No. 3, 4 and 7 the white powder of insecticides was used without any dilution. In all these plots, the infestation had considerably advanced by the end of December. Nicotine sulphate was then used in plot No. 3, but the reduction in the population of aphis was only temporary.

In the remaining plots No. 2, 5 and 6 where the insecticides were blackened, the infestation was comparatively much lower by the middle of January, and it remained fairly low throughout the season in plot No. 6, where besides blackening the dust, nicotine sulphate also was used twice.

TABLE LX

Weekly population of aphis on the dusted plants in 1929-30

(20 leaves examined each time)

Plot No.	Treatment	No. of aphis on 20 leaves every week								REMARKS
		15th Jan.	22nd Jan.	29th Jan	5th Feb.	13th Feb.	21st Feb	2nd Mar	12th Mar	
1	One acre plot blackened calcium arsenate at 20 lbs per acre	637	776	934	732	1,152	1,378	952	130	Nicotine sulphate used on 2nd and 21st Jan
2	Blackened calcium arsenate at 20 lbs per acre (10th plants)	53	112	84	100	242	1,245	356	133	
3	White calcium arsenate at 20 lbs per acre (100 plants).	544	142	48	211	349	587	174	65	Nicotine sulphate used on 24th Dec, 3rd Jan and 21st Jan.
4	White calcium arsenate at 10 lbs. per acre (100 plants).	392	205	288	474	827	1,863	453	192	
5	Blackened sodium silico-fluoride at 40 lbs. per acre (100 plants).	49	56	107	87	126	430	243	78	
6	Blackened sodium silico-fluoride at 40 lbs. per acre (100 plants).	24	17	41	85	54	73	15	traces	Nicotine sulphate used on 4th and 21st Jan.
7	White sodium silico-fluoride at 20 lbs. per acre (100 plants).	132	139	561	565	653	956	339	108	
	Control (Not dusted)	traces all along.								

It is thus seen that aphis infestation cannot be altogether prevented by blackening the insecticides, but it can be prevented from being as serious as when the

insecticides are used without any dilution. Blackened sodium silico-fluoride, being darker than blackened calcium arsenate, was found to be comparatively more effective in preventing serious infestation.

This drawback of these insecticides is likely to be removed to a considerable extent if the powders can be made jet black by adding small quantities of an inert colour. Nicotine sulphate mixed with these insecticides or with lime is not quite effective in removing the infestation entirely, and the use of such a costly insecticide on a large scale is prohibitive.

YIELD FROM DUSTED PLANTS AND THEIR CONTROLS

Acceleration of flowering and better retention of the earlier flowers was noticed during this season also (Appendix I, Table XL). But, as already stated, the aphis infestation appeared this year also and prevented any accurate measure of the effectiveness of the insecticides. Plots No. 5 and 7 alone showed an increase of 7 and 20 per cent respectively in the yield of *kapas*, whereas the increase was insignificant in plot No. 4, and there was a decrease in the yield of the remaining four plots.

TABLE LXI

Yield of kapas *from the plot of one acre dusted with blackened calcium arsenate and also from the three adjoining control plots*

1929-30

Treatment	Area under trial	Yield of *kapas* per acre
	Acre	Pounds
Dusted with blackened calcium arsenate at 20 lbs. per acre and used nicotine sulphate twice (Plot No. 1).	1	370 23
Control No. 1	1	382·10
Control No. 2	1	386·0
Control No. 3	1	362·65

TABLE LXII

Yield of mature bolls and kapas *from the dusted plots and their controls, in 1929-30*

(100 plants in each case)

Plot No.	Treatments	Total No. of bolls	Total yield of saleable *kapas* in grms.	Percentage increase or decrease over control
2	Blackened calcium arsenate at 20 lbs. per acre	2,871	5,645	
2A	Control	3,034	5,874	—3·9
3	White calcium arsenate at 20 lbs. per acre and nicotine sulphate against aphis.	2,650	5,154	
3A	Control	2,818	5,634	—8·5
4	White calcium arsenate at 10 lbs. per acre . .	2,647	5,092	
4A	Control	2,494	4,976	2·3
5	Blackened sodium silico-fluoride at 40 lbs. per acre.	2,781	5,400	
5A	Control	2,579	5,062	6·6
6	Blackened sodium silico-fluoride at 40 lbs. per acre and nicotine sulphate against aphis.	2,690	5,360	
6A	Control	2,710	5,551	—3·4
7	White sodium silico-fluoride at 20 lbs. per acre .	3,231	6,232	
7A	Control	2,600	5,185	20

The first four plots were devoted to studying the most effective way of using calcium arsenate. Out of these plots, No. 4 only showed a slight increase in the yield of *kapas*.

Sodium silico-fluoride was tried in the remaining three plots, and two of them (Plots No. 5 and 7) yielded 6·6 and 20 per cent more *kapas* respectively than their controls. The increase in yield in both the cases was not large enough to cover the cost of the insecticides, as can be seen from the following considerations :—

(1) Plot No. 5 yielded 338 grms. more *kapas* than its control. At this rate, the increased yield of *kapas* per acre would be 28 pounds and would fetch about Rs. 4-3-0, while the cost of the insecticides required would be about Rs. 27-12-0.

(2) Plot No. 7 yielded 1048 grms. of *kapas* more than its control. At this rate the extra yield of *kapas* would be about 86 pounds per acre, and would fetch about Rs. 12-14-0. The cost of the insecticides required for the treatment of one acre would be about Rs. 23-8-0.

Plots No. 5 and 6 both received similar treatments, and plot No. 6 received the further advantage of nicotine sulphate in the last two dustings. It is, however, strange to find that plot No. 5 has yielded more *kapas* than its control, whereas the yield of *kapas* from plot No. 6 has been less than that of its own control.

The experiments indicate that it is uneconomic to use these insecticides for controlling the Spotted Boll-worms. As the trials have been described, more or less in chronological order, the more important conclusions are summarised below.

Conclusions

(1) Lead arsenate and Paris Green, applied to the cotton plants in the form of dust or spray, are not useful in preventing damage by Spotted Boll-worms.

(2) Calcium arsenate dusted on the cotton plants, without any dilution, is effective in killing a large number of the *Earias* larvae. The tiny larvae, as soon as they emerge from the eggs, have the habit of wandering about on the plants, for some time, before they start feeding. These larvae come in contact of the dust and are killed in large numbers.

(3) The protection afforded by this insecticide to the cotton plants from the *Earias* larvae, results in the earlier flowering on the dusted plants and a better retention of bolls from these flowers.

(4) Within a period of about four weeks from the commencement of dusting of calcium arsenate, a serious infestation of aphis develops on the cotton plants. As a result of this infestation, the yield of *kapas* from these plants is generally reduced.

(5) It is found that the white colour of this insecticide attracts the winged aphis, which multiply rapidly on the plants. Blackening the dust of calcium arsenate, by adding an equal quantity of finely powdered charcoal before using, reduces the infestation but does not prevent it altogether; because the small local infestation, which exists on most of the cotton plants, gets extremely favourable conditions for multiplication, as they are protected from some of their important enemies by this insecticide.

(6) Sodium silico-fluoride also, in the form of white dust, is more effective in killing *Earias* larvae on the cotton plants than calcium arsenate.

(7) Earlier flower-opening and better retention of bolls from the early flowers is noticed in plots dusted with sodium silico-fluoride.

(8) One part of finely powdered charcoal and two parts of sodium silico-fluoride form a mixture which is darker than blackened calcium arsenate, and probably due to this reason, the aphis infestation remains at a slightly lower level on the plants dusted with this mixture than on those which receive blackened calcium arsenate.

(9) The leaves of cotton are scorched, and develop reddish brown patches, if showers of rain are received after the plants are dusted with sodium silico-fluoride. These leaves, however, do not shed but some of the flower-buds drop away due to this injury.

(10) The use of calcium arsenate or sodium silico-fluoride, only during the early part of the cotton-growing season, is harmful because the flower-buds and bolls saved from the Spotted Boll-worms during the above period are seriously damaged soon after the dustings are discontinued. It is, therefore, advisable to start the use of these insecticides late in the season and to continue it till the *Earias* population normally declines by the end of December or early in January.

(11) Nicotine sulphate used after mixing with calcium arsenate, sodium silico-fluoride or slaked lime (5 parts nicotine sulphate to 100 parts of one of the three powders) helped to dislodge most of the grown-up aphis from the plants, and thus to reduce the infestation to a great extent. This reduction was, however, only temporary.

(12) In several cases the yields of the plants, which were dusted either with white or blackened calcium arsenate or sodium silico-fluoride, were greatly reduced, in spite of the advantages mentioned above. This was apparently due to the serious aphis infestations which developed on the dusted plants.

(13) Higher yields of *kapas* were obtained from the plots, where the following treatments were attempted, than their respective controls. The extra yields, however, did not cover the cost of the insecticides, and hence the treatments were found to be uneconomic.

(1) 8·6 per cent higher yield of *kapas* during 1928-29 by using blackened calcium arsenate at flower-bud development (4 dustings).
(2) 14·9 per cent higher yield during 1928-29 by using blackened calcium arsenate during boll-development (4 dustings).
(3) 12·3 per cent higher yield during 1928-29 by using blackened sodium silico-fluoride at flower-bud development (4 dustings).
(4) 6·6 per cent higher yield during 1929-30 by using blackened sodium silico-fluoride at 40 lbs. of mixture per acre for each dusting (4 dustings).
(5) 20 per cent higher yield during 1929-30 by using white sodium silico-fluoride at 20 lbs. per acre for each dusting (4 dustings).

(14) There is a great possibility of these insecticides (calcium arsenate and sodium silico-fluoride) being very useful in controlling the Spotted Boll-worms if by some means the aphis infestation, which develops after their use, can be prevented altogether; or if a very cheap and effective method can be found for destroying the aphis.

(15) Of the two insecticides, sodium silico-fluoride is the more efficient.

8. Clean-up measures

The experience of Gough in Egypt [Gough, 1919] showed that there was a great possibility of controlling the Spotted Boll-worms on cotton, if suitable conditions are available for keeping all the cotton tract free from the food of these insects during the period between the two cotton-growing seasons.

At the Third Entomological Conference at Pusa [1919] Dr. Gough stated his experience as under :—

".....We had legislation against *Earias* and the result is that what was a bad pest in 1912 is only a quite minor pest now. In 1910-12 at the electric light on our verandah we used to attract twenty or thirty *Earias insulana* moths every evening, but now-a-days this species is comparatively a rarity, and the percentage of cotton bolls attacked by *Earias* is well below ten per cent. The legislation laid down demands that all cotton sticks be pulled out and burnt; and this applies also to *Hibiscus esculentus* and *Hibiscus cannabinus*. Thus for five months there is no food available for *Earias* as we do not leave any cotton or *Hibiscus* or any other food plant. Legislation on such lines forms the best means of control."

The attempts at direct control having failed to provide a practical remedy, it became necessary to consider if a preventive measure like the clean-up campaign could be profitably used for controlling this pest on cotton in Gujarat.

The last picking of cotton is generally over in this tract before the end of April, and sowing of the cotton crop of the next season commences some time from the middle of June to the middle of July according to the condition of the monsoon. Usually it is not till August that the plants grow to a size when the Spotted Boll-worms can thrive on them. It is, therefore, necessary to understand what happens to these insects during this period of nearly three months, and what may be the sources of fresh infection to the next crop. The possibilities are :—

(1) Aestivation between cotton seasons in one stage or another of their life.

(2) Active breeding throughout this period, in places where food may be available.

Nothing is so far known which would indicate the possibilities of aestivation of the Spotted Boll-worms. They have been collected in active condition throughout the year and have been reared in the laboratory during all the months. It was, therefore, decided to study the role of different plants in providing food for the pest in the field during the period of about three months between seasons.

(1) Wild food plants.

(2) Cultivation of *bhendi*.

(3) Fresh growth from cotton plants and their stumps.

Wild food-plants

The following wild food-plants of the Spotted Boll-worms are met with in the locality :—

(1) *Hibiscus rugosus.*
(2) *Hibiscus manihot.*
(3) *Hibiscus ficulneous.*
(4) *Hibiscus panduraeformis.*
(5) *Abutilon indicum.*
(6) *Abutilon graveolens.*

All these plants spring up after the commencement of the monsoon, and it is not till about the end of August that *Earias* population can be found on them. The pest appears almost simultaneously on these weeds and the fresh crop of cotton (Appendix I, Tables XLI to XLIV). *Earias* larvae can easily be collected from these weeds during October and November, and the *Abutilons*, in particular, are severely attacked during these months (Appendix I, Table XLIV).

By about the month of January, however, most of these plants dry up. Only a few stray plants of *Abutilon* are noticed with green leaves and pods, after January, in hedges or in neglected parts of gardens (Appendix I, Table XLV). A few plants of *Hibiscus panduraeformis* are also found in the fields during summer, but the population of boll-worms on these plants is very meagre.

Barring the stray plants of *Abutilon* and *Hibiscus panduraeformis*, the weeds do not afford any help for the Spotted Boll-worms to tide over the off-season.

CULTIVATION OF *bhendi* (*Hibiscus esculentus*)

It is usually with the first showers of the monsoon that the *bhendi* crop is sown on a large scale, and quantities of *bhendi* pods are available in the market by the middle of August. Though this is mainly a monsoon crop, a few scattered plots of this vegetable are met with even during the summer in the irrigated areas around wells. These plants are profusely attacked by the Spotted Boll-worms (Appendix I, Table XLVI).

This happens to be a favourite host for *Earias* caterpillars and the cultivation of *bhendi* certainly helps the carry-over of a very large number of these insects from one cotton-growing season to another.

Besides these stray plots of *bhendi* in summer, there is another possibility of the infection of the pest being carried by these pods. During May, June and July, the local supply of this vegetable becomes almost negligible, and pods are, therefore, imported in the important market centres, like Surat, from distant places like Ahmedabad, Nasik and Poona. These pods in the market also show the presence of *Earias* larvae in them. A coastal village named Hajira near Surat also specially grows *bhendi* during the summer and supplies these pods to Surat market in June

TABLE LXIII

Examination of bhendi *pods from Surat market*

Date of examination	Quantity of pods examined	No. of pods examined	No. of *Earias* larvae	Sources of pods
	Lbs.			
6th May 1929	3	200	3	Ahmedabad.
18th May 1929 . . .	5	240	3	Do.
25th May 1929	5·5	362	13	Hajira, District Surat.
1st June 1929	5	329	8	Do.
8th June 1929	4	255	12	Do.
15th June 1929	2	114	9	Do.
22nd June 1929	5	294	15	Do.
29th June 1929	5	260	8	Do.
5th July 1929	5	222	4	Poona or Nasik side.
12th July 1929	5	191	17	Do.
19th July 1929	5	189	5	Do.
27th July 1929	5	192	2	Do.
2nd August 1929 . . .	5	176	*nil.*	Do.
3rd May 1930 . . .	4	275	8	Ahmedabad side.
8th May 1930	5	274	13	Do.
15th May 1930	4	173	11	Do.
24th May 1930	3	232	10	Do.
31st May 1930	5	328	18	Do.
7th June 1930	5	290	11	Hajira, District Surat.
14th June 1930	5	228	3	Do.
21st June 1930	5	199	2	Do.
28th June 1930	5·	179	6	Bombay side.
5th July 1930	5	243	3	Do.
12th July 1930	5	228	3	Do.

Bhendi is thus seen to be an important source of food of the Spotted Boll-worms during the period between the two cotton-growing seasons, and it is, therefore, a source of infection to the cotton crop of the next season, not only in places where it is cultivated but also in distant places where its pods may be exported for table purposes.

Fresh growth from the cotton plants

When the last picking of cotton is over, the green growth on the cotton plants, consisting of tender shoots, flower-buds and young bolls, is practically absent, except on a few border plants. A few days later, however, most of these plants begin to sprout, and fresh vegetative shoots, flower-buds and young bolls begin to arise. The fresh growth from the standing cotton plants provides food and shelter to the Spotted Boll-worms until the plants are removed by the cultivators (Appendix I, Table XLVII), who do not show any particular anxiety to clean-up their cotton fields very early and the operation of the removal of the cotton plants proceeds slowly.

Table LXIV

The progress of the removal of cotton plants in a village called Piplod near Surat

Time of removal	Area cleared up in acres	Remarks
26th April 1928	36	Total area 116 acres. All picking of *kapas* over on the 10th April 1928.
9th May 1928	46	
23rd May 1928	12	
7th June 1928	22	
23rd March 1929	5	Total area 93·25 acres. All pickings of *kapas* over by the last week of March 1929.
6th April 1929	21	
20th April 1929	59	
3rd May 1929	7	
17th May 1929	1	
1st June 1929	½	

Fields are often seen where cotton plants are allowed to stand until the monsoon and a few cases are also found where the plants continue to stand even during the next season, the plots being neglected by the cultivators due to some reason or the other.

In one case a ratoon crop of cotton was observed in a plot at Bharthana near Surat during 1928-29. The plants were cut off, leaving a stump of about 8 to 12 inches from the ground. These plants put up luxurient growth with the commencement of the monsoon, and flowering was noticed on these plants in the second fortnight of September, when the flower-bud development on the new crop had just begun. Ten plants from this plot were kept under observation, and another group of ten plants from the new crop was reserved for similar observations for comparison (Appendix I, Table XLVIII). The first flush of vigorous flowering on the ratoon plants appeared very early and continued till the middle of October, while the flowering on the new crop commenced in the middle of November. The result of the early flowering on the ratoon crop was that the Spotted Boll-worms concentrated on these plants, and destroyed most of the young bolls and the developed flower-buds and the vigorous flowering abruptly came to a close at the end of the second week of October and could not commence again for about four weeks. The second flush of flowering which appeared on the ratoon plants along with the normal flowering of the new crop was very poor.

TABLE LXV

Flowering and boll-shedding on the ratoon plants and the new crop of cotton

(10 plants in each case)

——	Flowers opened	Bolls matured	Bolls shed	Bolls shed due to *Earias*
Ratoon crop	234	42	192	136
New crop	548	228	320	106

These observations indicate that the ratoon crop of cotton cannot yield a good crop of *kapas* as it is severely damaged by the Spotted Boll-worms, and also that it is harmful to the new crop of cotton as it affords a good breeding ground for this pest in the earliest part of the season.

It is fortunate that the fresh growth from the standing cotton plants in summer from most of the open fields (not fenced) is generally destroyed by the cattle; but the cotton plant shows a remarkable tenacity of life and the cotton sticks grazed by the cattle quickly develop fresh shoots.

Next to *bhendi*, therefore, these standing cotton plants are responsible for supplying food to these larvae for passing over from one cotton-growing season to another.

Fresh growth from stumps

The cotton plants are removed by the cultivators by hacking them with a *kudali* (light pick-axe) near the ground level (Plate XVI, Fig. I). A small stump of each one of these plants remains in the soil. Some of these stumps put up fresh growth within a few days after cutting, and plots from which the plants are removed the earliest usually contain a large number of sprouts, even before many of the other cotton fields are cleared off. Thus there is an overlapping of the sprouting from the standing cotton sticks and the stumps.

Table LXVI

Sprouts of cotton stumps from a plot on Surat Farm

(Plants removed by hacking with *kudali* on 23rd April 1928)

Date of observation	Total No. of hills in the plot	No. of hills showing sprouts	Percentage of sprouting
21st May 1928	2,105	812	39
8th June 1928	2,105	1,286	62
Plot harrowed on the 14th of June preparing the land for *jowar*			
28th June 1928	2,105	186	9
11th July 1928	2,105	184	9
Jowar sown in the third week of July			
31st July 1928	2,105	1,065	51

Table LXVII

Sprouts from cotton stumps from a cultivator's plot

(Plants removed by hacking with a *kudali* on 3rd April 1929)

Date of observation	Total No. of plants removed	No. of stumps showing sprouts	Percentage of sprouting
7th May 1929	6,091	2,239	37
22nd May 1929	6,091	3,243	53
30th May 1929	6,091	3,516	58
Not harrowed in the middle of June			
26th June 1929	6,091	947	16



FIG. 1. Removing the cotton plants with a light pick-axe.

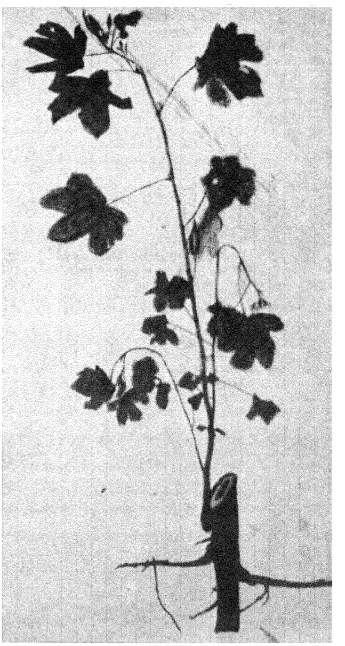


FIG. 2. A shoot sprouting from a stump of cotton plant.

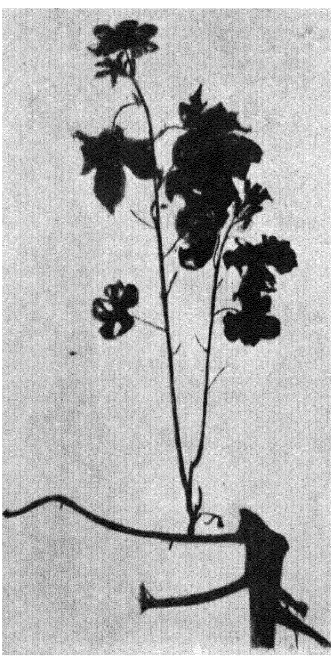


FIG. 1. A shoot sprouting from a side root of a stump of cotton plant.

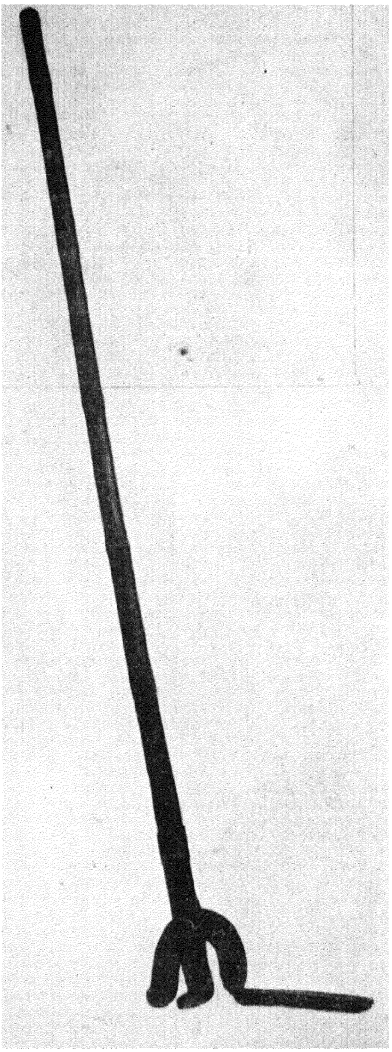


FIG. 2. A cotton plant-puller.

In another case, ninety-three acres of cotton were kept under observation during 1929 in a village called Piplod. The last picking of cotton was over at the end of March 1929.

TABLE LXVIII

Rough estimate of sprouting from stumps in 93 acres of cotton at Piplod 1929

Date of observation	Acres showing percentage sprouting from stumps			
	Less than 25 per cent	Between 25 and 50 per cent	Between 50 and 75 per cent	More than 75 per cent
27th April 1929	10	..	..	..
3rd May 1929	..	..	8	..
10th May 1929	8	..	3	..
17th May 1929	28	..	5	..
25th May 1929	61	5	5	..
1st June 1929	54	7	2	5
12th June 1929	51	13	9	5
22nd June 1929	35	18	..	1
27th June 1929	52	21	13	..
20th July 1929	67	8	..	7

It is interesting to note that most of the sprouts arise from the adventitious buds, because the plants are cut off below the cotyledonary nodes (Plate XVI, Fig. 2). More interesting still is the fact that we often come across shoots which have sprung up from the side roots of these stumps (Plate XVII, Fig. 1).

Earias larvae can be collected from these shoots as soon as they are about four to six inches in height (Appendix I, Tables XLIX and L). It is, therefore, seen that the fresh growth from the standing cotton plants and their stumps, the cultivation of *bhendi*, and the presence of stray plants of a couple of malvaceous weeds constitute the supply of food, which enable the Spotted Boll-worms to pass over from one cotton-growing season to another.

The cultivation of *bhendi* during this period is most harmful, because it harbours a very large population of these worms and the presence of even a few plants is enough to re-infect large areas of cotton. The responsibility of standing sticks, for providing food and shelter to these worms during the off-season, comes next.

The weeds and the sprouts from cotton stumps are comparatively less dangerous because the *Earias* population on them, during this critical period, is generally very meagre (Plates XVIII and XIX).

Having traced the means of carry-over of this pest from one season to another in Gujarat, where the period between the two cotton-growing seasons is comparatively short, observations were made in Khandesh where the off-season between the two crops is more than six months, and where the climatic and soil conditions are unsuited for the sprouting of the cotton plants or their stumps (Appendix IV).

These observations showed that the cotton areas in Khandesh are cleaned up before the end of March, and the stumps do not put forth new shoots, as they do in Gujarat, and hence there is no food available for the caterpillars in general cotton areas. There are, however, many irrigation wells in several villages, and the irrigated plots around these wells are found to be chiefly responsible for helping the carry-over of this pest in Khandesh, because old plants of cotton and plants of *Abutilon* are found growing in some of these plots, and *bhendi* is also grown in some during the period between the two cotton-growing seasons.

The knowledge of these facts leads to the conclusion that if the above sources of food, during the period between the two cotton-growing seasons, can be destroyed, the presence of the Spotted Boll-worms on the next crop of cotton can be eliminated. This would only be possible if a perfect clean-up campaign were organised over a very large area, and the cleaning-up is thoroughly carried out. It is essential to attend to the following points while arranging such a campaign :—

(1) Destruction of weeds

It has already been mentioned that out of the several wild food plants of the Spotted Boll-worms, only a very few plants of *Abutilon* and *Hibiscus panduraeformis* are met with in green condition during the summer. These must be destroyed. It must, therefore, be brought home to the cultivators that these plants growing in their plots and hedges are distinctly harmful to the cotton crop, and must, therefore, be removed as soon as they make their appearance.

(2) Elimination of *bhendi*

Bhendi in summer can only be grown where irrigation facilities are available. Even with these facilities it is very difficult to get a good crop in summer, because the growth of the plants is stunted due to the extreme heat; and also they are seriously infested by the Spotted Boll-worms. It is, therefore, advisable that the plants should not be grown by the cultivators during the months of April, May and June, in the interest of the large areas of their cotton crop.

Showing sources of plant food of the Spotted Boll-worms during the period between two cotton-growing seasons at Surat

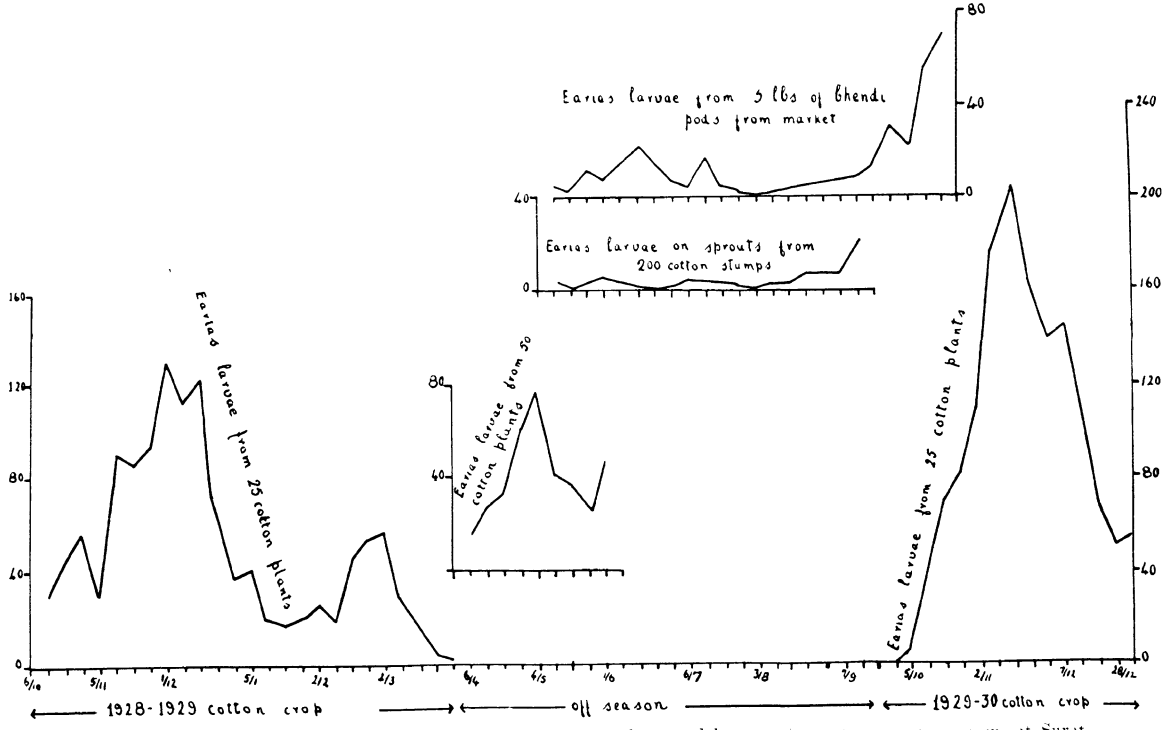


PLATE XIX

Showing sources of plant food of the Spotted Boll-worms during the period between two cotton-growing seasons at Surat

(3) Prevention of growth from the standing cotton plants and their stumps

Fresh growth from the standing cotton plants will not be available if the plants are removed immediately after the pickings of *kapas* are over. The absence of these plants will also prevent unnecessary drain of the plant food from the soil.

It is found that when the plants are removed by the usual method, fresh growth appears from the stumps which remain in the soil. A trial was made of removing the plants a little deeper, by hacking them after removing one or two clods near the stems with a light pick-axe.

Table LXIX

Sprouting from stumps in a plot where the plants were dug deeper on 27th April 1928

Surat Farm

Date of observation	Total No. of hills in the plot	No. of hills showing sprouts	Percentage of the sprouts
23rd May 1928.	2,771	44	1·6
8th June 1928	2,771	129	4·7
Plot harrowed on 14th June for preparing the land for *jowar*.			
28th June 1928	2,771	43	1·6
11th July 1928	2,771	48	1·7
Jowar sown in the third week of July.			
31st July 1928	2,771	53	1·9

Table LXX

Sprouting from stumps in a plot where the plants were dug deeper on 3rd April 1929

Cultivator's plot

Date of observation	No. of plants removed	No. of stumps showing sprouts	Percentage sprouting
7th May 1929	5,707	187	3
22nd May 1929	5,707	560	10
30th May 1929.	5,707	837	15
Plot harrowed in the middle of June.			
26th June 1929	5,707	190	3

The sprouting from stumps was considerably reduced by this method, but it was not eliminated. It was, therefore, considered that the sprouting could be prevented completely, only if the plants were pulled out with their roots. In several cases it was impossible to pull out the cotton plant in this locality even if two men tugged at it. It was, therefore, decided to prepare a mechanical device for doing this work. A large number of small tools of iron and wood were devised but they were not found to be quite suitable for this work. In the meanwhile we came across an old model prepared some time in 1911 at Coimbatore, devised on the principle of a nail-puller such as is used for extracting nails from deal-wood boxes. It could pull out the plants, but it had a very heavy handle of iron, and it often went out of order, as it was defective in several places. A large number of trials were made to perfect this tool, and the construction had to be radically changed before a satisfactory implement for uprooting cotton plants was evolved.

With this plant puller (Plate XVII, Fig. 2 and Plate XX), the cotton plants can be pulled out very easily. Most of the tap root and the main side roots are pulled out, while the thinner roots are left in the soil. A cultivator can work with this implement for the whole day without any abnormal exertion, and can clear up at least as much area as he can do with his *kudali* by the old method. The implement at present costs Rs. 1-4-0.

Trials are now in progress for testing these measures by organising a clean-up campaign in an area of about 480 square miles, which has about 80,000 acres under cotton in the Broach District. The results of these trials will be available in due course.

PLATE XX.



A cotton-plant puller in action.

APPENDIX I

TABLE I

Length of life of Earias *moths and the eggs laid by them, 1930-31*

Pair No.	Date of emergence of moths	No. of days the female moth lived	No. of days the male moth lived	Total No. of eggs laid by the female	REMARKS
1	4th November 1930	23	20	367	
2	5th November 1930	23	12	655	
3	7th November 1930	23	23	185	
4	7th November 1930	20	20	415	
5	8th November 1930	21	21	617	
6	10th November 1930	14	14	332	
7	10th November 1930	18	18	335	341 eggs per female moth, which emerged in November 1930.
8	22nd November 1930	16	13	414	
9	24th November 1930	20	20	400	
10	27th November 1930	24	10	424	
11	27th November 1930	17	17	100	
12	28th November 1930	10	4	160	
13	28th November 1930	14	14	134	
14	29th November 1930	15	5	231	
15	3rd December 1930	28	27	357	
16	7th December 1930	27	..	608	
17	7th December 1930	24	..	238	
18	8th December 1930	13	..	229	
19	8th December 1930	24	22	101	
20	8th December 1930	32	10	423	298 eggs per female moth, which emerged in December 1930.
21	8th December 1930	34	..	354	
22	12th December 1930	8	7	110	
23	18th December 1930	14	14	232	
24	20th December 1930	27	..	589	
25	21st December 1930	29	4	192	
26	21st December 1930	16	12	373	
27	31st December 1930	11	5	171	
28	31st December 1930	14	14	198	
29	1st January 1931	8	..	182	
30	1st January 1931	11	4	114	
31	3rd January 1931	11	..	279	
32	7th January 1931	7	..	156	185 eggs per female moth, which emerged in January 1931.
33	9th January 1931	12	9	96	
34	9th January 1931	20	..	363	
35	11th January 1931	18	..	205	
36	11th January 1931	13	9	81	

TABLE II

Time of oviposition of the Earias *moths.* (*Observed for 5 days*)

Day of observation	1st pair		2nd pair		3rd pair		4th pair		5th pair		6th pair		7th pair		8th pair		9th pair		10th pair		11th pair	
	Before 8 P.M.	After 8 P.M.	Before 9 P.M.	After 9 P.M.	Before 10 P.M.	After 10 P.M.	Before 11 P.M.	After 11 P.M.	Before 12 P.M.	After 12 P.M.	Before 1 A.M.	After 1 A.M.	Before 2 A.M.	After 2 A.M.	Before 3 A.M.	After 3 A.M.	Before 4 A.M.	After 4 A.M.	Before 5 A.M.	After 5 A.M.	Before 6 A.M.	After 6 A.M.
1st .	1	15	..	31	54	12	59	2	42	12	67	..	70	7	52	.	70	4	36	..	78	..
2nd . .	39	82	23	40	42	24	62	3	110	2	108	10	79	8	78	1	55	4	101	2	109	..
3rd . .	76	6	46	8	66	21	101	4	96	3	98	15	102	5	50	3	67	7	95	4	90	..
4th . .	50	35	55	13	60	11	75	11	61	6	59	7	62	4	61	5	39	3	89	1	86	..
5th . .	64	22	30	7	52	9	62	4	65	..	52	..	55	.	56	3	10	..	67	3	71	..
Total eggs .	230	160	154	99	274	77	359	24	374	23	384	32	368	24	306	14	250	18	388	10	434	..
Percentage oviposition before and after the allotted hour for each pair.	59	41	60·9	39 1	78	22	93·7	6·3	94·2	5 8	88 4	11 6	93·3	6 7	95 6	4 4	93 3	6 7	97 4	2 6	100	..

TABLE III

Average number of eggs laid by Earias *moths during August and September 1924*

Pair No.	No. of days after emergence when the 1st egg was laid	No. of eggs laid daily															Total eggs.	No. of days the female moth lived
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
1	5	41	44	47	29	29	18	16	14	14	11	7	4	4	5	4	287	23
2	6	23	4	38	49	63	48	34	21	22	..	..	..	..	..	..	302	18
3	5	49	63	71	1	76	19	4	2	8	22	4	7	9	1	..	336	21
4	5	53	46	39	43	51	29	32	29	19	..	..	..	..	..	..	341	16
5	4	113	81	76	79	56	32	37	21	19	..	..	..	..	..	..	514	15
6	1	55	87	98	127	87	38	69	37	25	43	13	6	12	..	..	697	15
7	3	50	91	45	56	47	57	46	23	24	19	16	..	..	..	..	474	16
8	3	4	76	63	51	38	37	13	32	9	4	..	..	..	..	..	327	15
9	2	12	5	62	77	86	72	52	38	51	32	34	24	16	19	..	580	18
10	1	84	98	75	60	48	25	29	38	28	6	..	..	..	..	..	491	13
11	1	104	64	83	25	47	43	29	24	22	..	..	..	..	..	..	441	12
12	1	132	110	70	52	43	14	..	..	..	..	..	..	..	..	..	421	9
13	1	139	162	108	44	21	..	..	..	..	..	..	..	..	..	..	474	8
14	2	12	24	26	42	57	45	58	27	18	16	22	9	14	..	..	370	17
TOTAL	..	871	955	901	735	749	477	419	306	259	153	96	50	55	25	4	6,055	..
Average per pair.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	432·5	15·5

TABLE IV

Periodical bud formation, flower-opening, and shedding of flower-buds and bolls; and the causes of shedding

(49 plants observed at Surat during 1925-26)

	5th September	12th September.	19th September	26th September	3rd October	10th October	17th October.	24th October.	31st October.	7th November	14th November.	21st November	28th November	5th December	12th December.	19th December.	26th December.	2nd January.	9th January.	16th January.	23rd January.	30th January.	6th February.	Total.
Flower-bud formation.	96	225	339	465	761	837	1,192	1,494	1,254	1,415	1,523	1,294	779	423	186	47	6	5	.	..	..	..	..	12,341
Flower-bud shedding .	8	85	184	266	359	456	829	1,059	920	749	758	675	447	493	646	512	227	98	15	..	..	..	..	8,786
Flower-buds shed due to boll-worms.	..	.	41	71	110	201	436	571	503	502	371	357	203	196	146	77	22	2	..	..	..	..	..	3,899
Flower-buds shed due to other causes.	5	62	117	173	217	216	358	447	290	211	233	286	221	252	424	381	170	66	..	..	..	..	..	4,129
Flower opening . .	..	..	..	..	..	..	22	22	15	17	85	214	562	757	764	643	378	128	25	3	..	..	..	3,635
Total boll shedding .	..	..	..	..	..	..	7	20	15	11	17	34	58	161	278	425	595	484	116	24	11	1	..	2,257
Bolls shed due to boll-worms.	..	..	..	..	..	..	7	18	13	8	15	21	40	88	75	66	74	43	14	3	1	..	..	486
Bolls shed due to other causes.	..	..	..	..	..	..	..	2	2	3	2	13	18	73	203	359	521	441	102	21	10	1	..	1,771

TABLE V

Periodical flower-bud formation, flower- opening, and shedding of flower-buds and bolls ; with causes of their shedding

(20 plants observed during 1926-27 at Surat)

—	2nd October.	9th October.	16th October.	23rd October.	30th October.	6th November.	13th November.	20th November.	27th November.	4th December	11th December	18th December	25th December.	1st January.	8th January.	15th January.	22nd January.	29th January.	5th February.	12th February.	19th February.	26th February.		TOTAL.
Flower-bud formation . . .	29	55	110	284	452	511	614	656	596	677	544	497	225	254	130	119	86	45	26	8	12	15	..	5,945
Flower-bud shedding (total) . .	..	6	34	31	96	148	274	326	441	414	455	528	476	324	281	136	161	183	194	157	68	18	15	4,766
Flower-buds shed due to boll-worms .	.	.	6	3	14	40	109	157	260	247	267	328	276	189	162	67	62	49	39	11	2	..	..	2,288
Flower-buds shed due to other causes .	..	3	26	17	52	85	129	140	140	143	164	185	183	122	112	62	93	127	149	143	61	16	13	2,165
Flower opening	..	..	..	..	3	7	32	40	40	71	67	88	89	68	96	85	92	114	125	115	40	8	..	1,180
Boll-shedding	.	..	..	.	.	..	8	14	23	37	55	62	81	65	60	45	38	38	55	46	64	10	5	706
Bolls shed due to boll-worms . .	..	.	.		.	.	6	10	21	32	46	56	74	58	52	36	29	17	27	12	6	..	..	482
Bolls shed due to other causes . .	..	..	.	..		.	2	4	2	5	9	6	7	7	8	9	9	21	28	34	58	10	5	224

TABLE VI

Periodical flower-bud formation, flower-opening and shedding of flower-buds and bolls; with causes of their shedding

(16 plants observed at Surat during 1927-28)

—	17th September.	24th September.	1st October.	8th October.	15th October.	22nd October.	29th October.	5th November.	12th November.	19th November.	26th November.	3rd December.	10th December.	17th December.	24th December.	31st December.	7th January.	14th January.	21st January.	28th January.	4th February.	11th February.	18th February.	25th February.	Total.
Flower-bud formation . .	114	187	317	317	279	349	278	574	612	473	493	573	563	474	427	239	156	68	49	24	3	..	1	..	6,570
Flower-bud shedding (total) .	26	98	225	225	180	352	239	239	299	319	310	302	351	219	187	290	276	301	243	195	70	54	27	..	5,027
Flower-buds shed due to boll-worms.	3	24	12	12	18	75	55	88	131	95	116	158	163	91	65	46	69	37	26	13	9	2	..	..	1,308
Flower-buds shed due to other causes.	14	52	121	121	124	234	143	78	84	64	117	69	130	102	105	207	167	210	191	154	51	39	17	..	2,594
Flower opening . . .	..	..	..	..	..	..	..	..	1	6	12	31	67	67	116	142	198	279	223	221	109	46	22	2	1,542
Bolls shed (Total) . . .	..	..	..	..	..	..	..	..	..	1	5	4	23	30	24	68	49	91	124	128	156	156	71	273	950
Bolls shed due to boll-worms .	..	..	..	..	..	..	..	..	..	1	5	3	17	19	17	34	18	31	25	11	4	4	..	3	192
Bolls shed due to other causes .	..	..	..	..	..	..	..	..	..	..	..	1	6	11	7	24	31	60	99	117	152	152	71	243	758

TABLE VII

Rainfall at Surat for 6 years. (June to December)

1925		1926		1927		1928		1929		1930	
Weeks	Rain	Weeks	Rain	Weeks	Rain	Weeks	Rain	Weeks	Rain	Weeks	Rain
6th June	8 40	6th June	..	4th June	..	2nd June	..	1st June	..	30th May	..
13th June	0·56	13th June	..	11th June	0 45	9th June	..	8th June	0 21	6th June	..
20th June	3 41	20th June	..	18th June	4 73	16th June	2 91	15th June	0 57	13th June	0·02
27th June	3·76	27th June	..	25th June	3 86	23rd June	..	22nd June	4 25	20th June	1·15
4th July	1·27	4th July	6 17	2nd July	0 98	30th June	..	29th June	4 01	27th June	7·55
11th July	0·59	11th July	4 45	9th July	3 39	7th July	5 11	6th July	6 95	4th July	16·36
18th July	1·12	18th July	6 73	16th July	2 48	14th July	2 48	13th July	22 48	11th July	1·59
25th July	0 55	25th July	0 85	23rd July	1 18	21st July	1 54	20th July	4 58	18th July	0·85
1st August	0 53	1st August	11·99	30th July	5 14	28th July	2 12	27th July	1 22	25th July	3·03
8th August	3 32	8th August	0 76	6th August	0 31	4th August	0 65	3rd August	1 11	1st August	1·83
15th August	0 50	15th August	10 66	13th August	0 97	11th August	0 67	10th August	0 28	8th August	1·58
22nd August	0 25	22nd August	1 77	20th August	1 13	18th August	1 40	17th August	0 81	15th August	0 61
29th August	0·08	29th August	5 12	27th August	0 70	25th August	0 47	24th August	0 93	22nd August	0 17
5th Sept.	0 45	5th Sept.	3 05	3rd Sept.	0 55	1st Sept	1 43	31st August	0 21	29th August	..
12th Sept.	0 60	12th Sept	0 53	10th Sept	0 42	8th Sept	0 31	7th Sept	..	5th Sept.	0·16
19th Sept.	..	19th Sept.	9·62	17th Sept	0 49	15th Sept	0 02	14th Sept.	.	12th Sept.	1 07
26th Sept.	..	26th Sept	1 25	24th Sept	0 74	22nd Sept.	4 76	21st Sept.	0 45	19th Sept.	4 20
3rd Oct	..	3rd Oct	..	1st Oct.	2 51	29th Sept.	1 14	28th Sept	..	26th Sept.	0 06
10th Oct	..	10th Oct.	..	8th Oct	2 15	6th Oct	0 27	5th Oct	0 32	3rd Oct	..
17th Oct	..	17th Oct.	..	15th Oct	.	13th Oct	0 22	12th Oct	..	10th Oct.	..
24th Oct	..	24th Oct.	..	22nd Oct	.	20th Oct	.	19th Oct	..	17th Oct.	..
31st Oct	..	31st Oct	..	29th Oct.	.	27th Oct	0 38	26th Oct	.	24th Oct.	..
7th Nov	..	7th Nov	..	5th Nov.	.	3rd Nov	.	2nd Nov.	..	31st Oct.	0 95
14th Nov.	..	14th Nov.	..	12th Nov	1 18	10th Nov	..	9th Nov.	..	7th Nov.	..
21st Nov	0·06	21st Nov.	..	19th Nov	1 70	17th Nov.	..	16th Nov.	.	14th Nov.	..
28th Nov.	..	28th Nov.	..	26th Nov	.	24th Nov.	..	23rd Nov.	.	21st Nov.	..
4th Dec.	..	4th Dec.	..	3rd Dec	..	1st Dec.	0·29	30th Nov.	..	28th Nov.	..
11th Dec.	..	11th Dec.	..	10th Dec.	.	8th Dec.	0 02	7th Dec.	..	5th Dec.	0·10
18th Dec.	..	18th Dec	..	17th Dec.	..	15th Dec	0·02	14th Dec.	..	12th Dec.	..
TOTAL	25·44	..	62 95	..	35 06	..	26·21	..	48·26	..	41 28

TABLE VIII

Population of Earias *larvae on cotton plants at Surat*

(25 cotton plants examined every week, 1925-26)

Week ending	No. of plants	*Earias* larvae in			Total Earias	Empty buds	Total buds	Empty bolls	Total bolls
		Shoots	Buds	Bolls					
19th September 1925 .	25	28	4	..	32	56	243	..	..
25th September 1925 . .	25	44	4	..	48	80	355	..	..
2nd October 1925 . . .	25	42	6	..	48	99	427	..	..
9th October 1925 . . .	25	27	16	..	43	106	662	..	..
16th October 1925. . .	25	54	14	..	68	136	633	..	..
23rd October 1925. . .	25	58	29	..	87	230	692	..	..
30th October 1925 . .	25	31	42	..	73	200	856	..	..
7th November 1925 . .	25	11	34	..	45	185	1,042	..	..
14th November 1925 . .	25	5	40	..	45	156	1,940	1	..
21st November 1925 . .	25	2	27	3	32	202	2,221	4	44
28th November 1925 . .	25	..	27	27	54	90	2,341	22	181
4th December 1925 . .	25	..	26	21	47	40	2,469	20	334
11th December 1925 . .	25	..	18	26	44	31	1,684	16	420
18th December 1925 . .	25	..	18	37	55	18	1,577	35	696
25th December 1925 . .	25	..	13	38	51	12	927	60	1,186
1st January 1926 . . .	25	..	3	35	38	4	401	54	1,127
8th January 1926 . . .	25	..	3	27	30	1	97	32	966
15th January 1926 . .	25	..	..	22	22	..	49	44	821
22nd January 1926 . .	25	..	..	25	25	..	..	54	838
29th January 1926 . .	25	..	..	14	14	..	24	31	795

TABLE IX

Population of Earias *larvae on cotton plants at Surat*

(25 plants examined every week, 1926-27)

Week ending	No. of plants	*Earias* larvae in			Total Earias	Empty buds	Total buds	Empty bolls	Total bolls
		Shoots	Buds	Bolls					
9th October 1926 . . .	25	..	..	..	..	1	56	..	..
16th October 1926. . .	25	2	1	..	3	2	97	..	..
23rd October 1926. .	25	5	..	..	5	2	162	..	..
30th October 1926. . .	25	15	1	..	16	9	517	..	..
6th November 1926 . .	25	9	10	..	19	75	804	..	..
13th November 1926 . .	25	9	28	1	38	84	1,065	..	4
20th November 1926 . .	25	18	44	..	62	103	1,349	..	2
27th November 1926 . .	25	17	73	1	91	178	1,367	1	4
4th December 1926 . .	25	15	59	2	76	157	1,445	..	6
11th December 1926 . .	25	18	115	5	138	167	1,505	..	9
18th December 1926 . .	25	21	99	3	123	305	2,116	1	10
25th December 1926 . .	25	12	124	8	144	311	1,047	7	24
1st January 1927 . . .	25	..	..	..	..	..	..	..	..
8th January 1927 . . .	25	2	60	5	67	160	2,114	4	25
15th January 1927 . .	25	1	73	12	86	215	2,220	4	58
22nd January 1927 . .	25	..	44	3	47	114	2,165	3	90
29th January 1927 . .	25	1	31	15	47	95	2,090	8	229
5th February 1927 . .	25	..	21	23	44	74	1,890	19	439
12th February 1927 . .	25	..	10	5	15	53	1,991	11	794
19th February 1927 . .	25	..	9	12	21	23	1,271	32	1,081
26th February 1927 . .	25	..	2	7	9	10	682	15	1,071
5th March 1927 . . .	25	..	1	4	5	1	195	11	888
12th March 1927 . . .	25	..	..	5	5	..	9	21	801
19th March 1927 . . .	25	..	..	4	4	..	..	40	731
26th March 1927 . . .	25	..	..	7	7	..	..	73	690

TABLE X

Population of Earias *larvae on cotton plants at Surat*

(25 plants examined every week, 1927-28)

Week ending	*Earias* larvae in			Total Earias	Empty buds	Total buds	Empty bolls	Total bolls	REMARKS
	Shoots	Buds	Bolls						
17th September 1927	7	1	..	8	..	166	..	..	
24th September 1927	22	3	..	25	6	333	..	..	
1st October 1927 .	23	1	..	24	15	432	..	..	
8th October 1927 .	21	1	..	22	28	588	..	..	
15th October 1927 .	68	6	..	74	56	777	..	..	
22nd October 1927 .	49	8	..	57	71	819	..	..	
29th October 1927 .	46	12	..	61	169	1,158	..	..	3 moving on plant.
5th November 1927 .	31	20	..	51	141	1,263	..	..	
12th November 1927	38	40	..	78	227	1,976	..	..	
19th November 1927	6	38	1	46	171	2,392	1	2	1 moving on plant.
26th November 1927.	3	65	1	69	197	2,421	..	13	
3rd December 1927 .	5	55	3	63	122	2,302	5	38	
10th December 1927.	..	35	7	42	123	2,496	3	107	
17th December 1927.	..	30	4	34	130	3,501	7	170	
24th December 1927.	..	23	11	34	111	3,541	8	189	
31st December 1927.	..	29	12	41	79	3,530	23	406	
7th January 1928 .	..	22	16	38	66	3,204	11	487	
14th January 1928 .	..	12	23	35	51	2,763	60	1,156	
21st January 1928 .	..	3	15	18	32	1,849	44	1,164	
28th January 1928 .	..	1	11	12	34	968	86	1,357	
4th February 1928 .	..	1	10	11	26	607	80	1,629	
11th February 1928 .	..	..	4	4	1	105	70	1,270	
18th February 1928 .	..	..	2	2	..	56	47	1,001	
25th February 1928 .	..	1	7	8	..	14	59	857	
3rd March 1928 .	..	..	2	2	..	4	51	527	
10th March 1928 .	..	..	9	9	..	..	39	300	
17th March 1928 .	..	..	15	15	..	..	28	183	
24th March 1928 .	..	..	7	7	..	..	10	72	
31st March 1928 .	1	..	6	7	2	27	3	25	

TABLE XI

Population of Earias *larvae on cotton plants at Surat*

(1928-29)

Week ending	No. of plants	*Earias* larvae in			Total Earias	Empty buds	Total buds	Empty bolls	Total bolls	REMARKS
		Shoots	Buds	Bolls						
4th August 1928 .	1,000	..	..	..	..	..	..	..	..	
11th August 1928 .	1,000	..	..	..	..	..	..	..	..	
18th August 1928 .	1,000	..	.	..	..	..	..	..	..	
25th August 1928 .	750	..	..	..	..	..	3	..	..	
1st September 1928 .	750	5	..	..	5	..	9	..	..	
8th September 1928 .	250	4	..	..	4	..	21	..	..	
15th September 1928 .	125	9	..	..	9	..	90	..	..	
22nd September 1928 .	..	..	..	..	..	..	..	..	..	
29th September 1928 .	100	4	..	..	4	2	274	..	..	
6th October 1928 .	50	6	1	..	7	2	203	..	..	
13th October 1928 .	25	26	3	..	29	14	562	..	..	
20th October 1928 .	25	30	15	..	45	40	1,113	..	..	
27th October 1928 .	25	31	24	..	56	61	1,845		.	
3rd November 1928	25	10	22	..	32	92	1,758	..	1	
10th November 1928 .	25	13	75	1	89	135	2,758	..	..	
17th November 1928 .	25	6	67	10	86	108	2,767	4	50	3 moving.
24th November 1928 .	25	2	84	8	95	86	3,096	7	119	1 moving.
1st December 1928 .	25	..	100	30	130	90	3,235	12	210	
8th December 1928 .	25	.	72	43	115	75	3,201	26	314	
15th December 1928 .	25	2	89	32	123	74	2,797	14	338	
22nd December 1928 .	25	..	34	30	65	59	2,915	20	610	
29th December 1928 .	25	..	22	15	37	12	3,162	19	863	
5th January 1929 .	25	..	21	19	40	6	1,744	12	863	
12th January 1929 .	25	..	8	11	19	5	1,025	26	851	
19th January 1929 .	25	..	8	10	18	5	804	42	1,062	
26th January 1929 .	25	..	4	16	20	4	681	26	1,005	
2nd February 1929 .	25	..	1	24	25	2	188	16	1,027	
9th February 1929 .	25	..	..	19	19	..	30	5	794	
16th February 1929 .	25	..	1	45	46	..	3	1	761	
23rd February 1929 .	25	..	1	53	54	..	1	..	586	
2nd March 1929 . .	25	..	..	56	56	..	..	12	416	
9th March 1929 .	25	..	..	28	28	..	..	..	175	
16th March 1929 .	25	..	..	17	17	..	5	.	85	
23rd March 1929 .	25	..	..	4	4	..	17	..	10	
30th March 1929 .	50	..	2	..	2	2	75	..	2	

TABLE XII

Population of Earias *larvae on cotton plants at Surat*

(1929-30)

Week ending	No. of plants	*Earias* larvae in			Total Earias	Empty buds	Total buds	Empty bolls	Total bolls	REMARKS
		Shoots	Buds	Bolls						
3rd August 1929 .	1,300	..	..	..	..	..	..	..	..	
10th August 1929 .	887	..	..	..	..	..	..	..	..	
17th August 1929 .	1,394	9	..	..	9	..	..	..	..	
24th August 1929 .	396	..	..	..	..	..	..	..	..	
31st August 1929 .	860	4	..	..	4	..	..	..	..	
7th September 1929 .	750	3	..	..	3	..	..	..	..	
14th September 1929 .	500	5	..	..	5	..	19	..	..	
21st September 1929 .	250	13	..	..	13	1	493	..	..	
28th September 1929 .	125	5	1	..	6	7	664	..	..	
5th October 1929 .	50	10	4	..	14	2	569	..	..	
12th October 1929 .	25	26	9	..	35	6	595	..	..	
19th October 1929 .	25	42	28	..	70	27	1,023	..	2	
26th October 1929 .	25	20	58	3	81	53	1,137	..	6	
2nd November 1929 .	25	26	86	2	114	141	1,067	..	8	
9th November 1929 .	25	31	143	2	176	194	1,993	..	5	
16th November 1929 .	25	25	167	6	204	325	2,027	1	17	6 moving.
23rd November 1929 .	25	12	143	7	167	107	2,529	1	20	5 moving.
30th November 1929 .	25	5	143	7	159	223	3,381	3	32	4 moving.
7th December 1929 .	25	..	153	11	165	124	3,037	8	72	1 moving.
14th December 1929 .	25	.	92	15	107	121	3,829	13	149	
21st December 1929 .	25	..	45	24	69	68	2,673	12	388	
28th December 1929 .	25	..	30	21	51	48	2,831	19	493	
4th January 1930	25	..	24	20	54	45	2,537	29	866	1 moving.
11th January 1930 .	25	..	15	23	38	10	1,721	28	1,350	
18th January 1929 .	25	..	3	11	14	2	940	19	1,814	
25th January 1930 .	25	..	2	7	9	1	288	35	1,468	
1st February 1930 .	25	..	..	3	3	..	67	27	1,102	
8th February 1930 .	25	..	..	18	18	..	20	36	1,170	
15th February 1930 .	25	..	..	25	25	..	5	27	947	
22nd February 1930 .	25	..	..	28	28	..	..	10	882	
1st March 1930 . .	25	..	..	32	32	..	..	30	693	
8th March 1930 .	25	..	..	13	13	..	..	12	384	
15th March 1930 .	25	..	..	4	4	..	..	6	67	
22nd March 1930 .	25	..	..	1	1	..	..	5	13	
29th March 1930 .	25	..	..	..	..	..	..	..	3	

TABLE XIII

Population of Earias *larvae on cotton plants at Surat*

(1930-31)

Week ending	No. of plants	*Earias* larvae in			Total Earias	Empty buds	Total buds	Empty bolls	Total bolls	REMARKS
		Shoots	Buds	Bolls						
13th August 1930 .	1,000	..	..	..	..	..	..	..	..	
20th August 1930 .	1,000	2	..	..	2	..	..	..	..	
27th August 1930 .	1,000	5	..	..	5	..	..	..	..	
3rd September 1930 .	500	18	..	..	18	..	..	..	..	
10th September 1930 .	200	8	..	..	8	..	124	..	..	
17th September 1930 .	100	6	..	..	7	..	62	..	..	1 moving
24th September 1930 .	50	32	1	..	36	..	470	..	..	3 moving
3rd October 1930 .	25	8	4	..	13	11	565	..	..	1 *Earias* moving.
10th October 1930 .	25	9	17	..	28	36	1,301	..	..	2 *Earias* moving.
17th October 1930 .	25	17	57	..	78	86	2,202	..	3	4 *Earias* moving.
24th October 1930 .	25	24	158	9	196	155	2,260	7	50	5 *Earias* moving.
31st October 1930 .	25	43	155	14	220	186	1,977	5	43	8 *Earias* moving.
7th November 1930 .	25	31	122	12	167	174	1,777	7	51	2 *Earias* moving.
14th November 1930 .	25	11	123	6	140	190	2,107	14	33	
21st November 1930 .	25	1	78	9	90	97	2,688	2	32	2 *Earias* moving.
28th November 1930 .	25	..	90	15	108	..	3,998	..	75	3 *Earias* moving.
5th December 1930 .	25	..	132	24	157	94	5,192	7	208	1 *Earias* moving.
12th December 1930 .	25	..	91	28	122	67	4,224	16	288	3 *Earias* moving.
19th December 1930 .	25	..	52	33	85	71	4,207	35	868	
26th December 1930 .	25	..	33	19	53	53	3,919	37	1,707	1 *Earias* moving.
2nd January 1931 .	25	..	13	17	30	17	2,198	24	1,895	
9th January 1931 .	25	..	6	17	23	5	927	33	2,167	
16th January 1931 .	25	..	1	13	14	1	225	37	1,692	
23rd January 1931 .	25	..	..	20	20	..	18	26	1,248	
30th January 1931 .	25	..	..	28	28	..	1	38	1,165	

TABLE XIV

Weekly flower-bud formation, flower-opening and shedding of flower-buds and bolls from the caged and control plants

(1925-26)

—	4th September	11th September	18th September	25th September	2nd October	9th October	16th October	23rd October	30th October	6th November	13th November	20th November	27th November	4th December	11th December	18th December	25th December	1st January	8th January	15th January	TOTAL
CAGED PLANTS 8.																					
Flower-bud formation . . .	27	72	91	109	223	239	292	263	237	172	60	18	20	8	..	..	..	..	..	..	1,831
Flower-bud shedding . . .	2	19	34	47	36	46	68	101	111	179	193	228	14	28	16	..	..	..	..	..	1,122
Flower-opening	..	..	.	.	.	1	16	46	133	178	188	113	28	3	3	..	..	..	..	..	709
UNCAGED PLANTS 49.																					
Flower-bud formation . . .	96	225	339	465	761	837	1,192	1,494	1,254	1,415	1,523	1,204	779	423	186	47	6	5	..	..	12,341
Flower-bud shedding (Total) . .	8	85	184	266	359	456	829	1,059	920	749	758	675	447	493	646	512	227	98	15	..	8,786
Flower-buds shed due to boll-worms .	..	..	41	71	110	201	436	571	593	502	371	357	203	196	146	77	22	2	..	..	3,899
Flower-buds shed due to other causes.	5	62	117	173	217	216	358	447	290	211	233	286	221	252	424	381	170	66	..	..	4,129
Flower-opening	..	..	..	..	..	..	22	22	15	17	85	214	562	757	764	643	378	128	25	3	3,645

TABLE XV

Weekly flower-bud formation, flower-opening and shedding of flower-buds and bolls from the caged and control plants

(1926-27)

—	2nd October	9th October	17th October	23rd October	30th October	6th November	13th November	20th November	27th November	4th December	11th December	18th December	25th December	1st January	8th January	15th January	22nd January	29th January	5th February	12th February	19th February	26th February	5th March	TOTAL
CAGED PLANTS 10.																								
Flower-bud formation . . .	..	112	156	189	276	368	341	317	232	238	128	38	29	4	2	..	..	..	..	..	.	.	.	2,430
Flower-bud shedding . . .	..	7	20	32	24	61	87	160	172	168	218	306	188	79	9	8	.	.	..	.	.	.	..	1,539
Flower-opening	..	..	..	..	7	30	60	97	108	133	129	148	106	49	19	4	..	1	..	..	.	..	.	891
UNCAGED PLANTS 20.																								
Flower-bud formation . . .	29	55	110	284	452	511	614	656	596	677	544	497	225	254	130	119	86	45	26	8	12	15	..	5,945
Flower-bud shedding (Total) . .	..	6	34	31	96	148	274	326	441	414	455	528	476	324	281	136	161	183	194	157	68	18	15	4,766
Flower-bud shed due to boll-worms	..	..	6	3	14	40	109	157	260	247	267	328	276	189	162	67	62	49	39	11	2	..	..	2,288
Flower-buds shed due to other causes	..	3	26	17	52	85	129	140	140	143	164	185	183	122	112	62	93	127	149	143	61	16	13	2,165
Flower-opening	..	..	..	..	3	7	32	40	40	71	67	88	89	68	96	85	92	114	125	115	40	8	..	1,180

TABLE XVI

Weekly flower-bud formation, flower-opening and shedding of flower-buds and bolls from the caged and control plants

(1927-28)

—	9th September	16th September	23rd September	30th September	7th October	14th October	21st October	28th October	5th November	12th November	19th November	26th November	3rd December	10th December	17th December	24th December	31st December	7th January	14th January	21st January	28th January	4th February	11th February	18th February	25th February	TOTAL
CAGED PLANTS 20.																										
Flower-bud formation.	11	117	220	478	478	375	647	717	1,219	1,021	508	743	802	1,035	360	149	28	1	..	..	..	..	..	..	..	8,909
Flower-bud shedding.	..	25	83	339	339	305	384	348	317	229	294	609	115	230	389	518	799	194	102	36	..	..	..	..	..	5,605
Flower-opening .	..	..	..	..	..	..	..	..	..	23	111	205	304	448	450	523	570	409	202	63	19	6	1	..	..	3,334
UNCAGED PLANTS 16.																										
Flower-bud formation.	..	114	187	317	317	279	349	278	574	612	473	493	573	563	474	427	239	156	68	49	24	3	..	1	..	6,570
Flower-bud shedding (Total).	..	26	98	225	225	180	352	239	239	299	319	310	302	351	219	187	290	276	301	243	195	70	54	27	..	5,027
Flower-buds shed due to boll-worms.	..	3	24	12	12	18	75	55	88	131	95	116	158	163	91	65	46	69	37	26	13	9	2	..	..	1,308
Flower-buds shed due to other causes.	..	14	52	121	121	124	234	143	78	84	64	117	69	130	102	105	207	167	210	191	154	51	39	17	..	2,594
Flower-opening .	..	..	..	..	..	..	..	..	..	1	6	12	31	67	67	116	142	198	279	223	221	109	46	22	2	1,542

TABLE XVII

Flower-opening, relative success from flowers to mature bolls and shedding of bolls with causes from caged plants and their controls

(1925-26, Surat)

—	3rd October	10th October	17th October	24th October	31st October	7th November	14th November	21st November	28th November	5th December	12th December	19th December	26th December	2nd January	9th January	16th January	23rd January	30th January	TOTAL
CAGED PLANTS 8.																			
Flowers opened . . .	..	1	16	46	133	178	188	113	28	3	3	..	..	..	..	..	..	..	709
Bolls shed (relative) . . .	..	..	7	13	53	116	170	78	15	3	3	..	..	..	..	..	..	..	458
Flowers which developed into mature bolls (relative).	..	1	9	33	80	62	18	35	13	..	..	..	..	..	..	..	..	..	251
Percentage of bolls to flowers .	..	100	56·3	71 7	60·1	34·8	9·6	31·0	46·4	..	..	..	..	..	..	..	..	..	35·4
UNCAGED PLANTS 10.																			
Flowers opened . . .	..	..	22	22	15	17	85	214	562	757	764	643	378	128	25	3	..	..	3,635
Bolls shed (relative) . . .	..	..	21	19	11	11	37	72	166	336	530	559	344	123	21	3	..	..	2,253
Causes of boll shedding due to boll-worms.	..	..	20	16	8	10	26	45	98	87	70	61	20	5	..	..	..	..	466
Causes of boll-shedding due to other causes.	..	..	1	3	3	1	11	27	68	249	460	498	324	118	21	3	..	..	1,787
Flowers which developed into mature bolls (relative).	..	..	1	3	4	6	48	142	396	421	234	84	34	5	4	..	..	..	1,382
Percentage of bolls to flowers .	..	..	4 5	13·6	26·6	35 2	56 4	66·3	70·4	55·6	30·6	13·0	8 9	3·9	16·0	..	..	..	38·0

TABLE XVIII

Flower-opening, relative success from flowers to mature bolls and shedding of bolls with causes of shedding from caged plants and their controls

(1926-27, Surat)

—	23rd October	30th October	6th November	13th November	20th November	27th November	4th December	11th December	18th December	25th December	1st January	8th January	15th January	22nd January	29th January	5th February	12th February	19th February	26th February	TOTAL
CAGED PLANTS 10																				
Flowers opened	..	7	30	60	97	108	133	129	148	106	49	19	4	.	1	.	..	..	..	891
Bolls shed (relative)	..	1	6	11	29	32	78	117	129	95	41	14	4	.	1		..	..	..	558
Flowers which developed into mature bolls (relative).	..	6	24	49	68	76	55	12	19	11	8	5	..	..	.	..	..	..	..	333
Percentage of bolls to flowers	..	85·7	80·0	81·7	70·1	70·4	41·4	9·3	12·8	10·4	16·3	26·3		.		.	.	.	..	37·4
UNCAGED PLANTS 20																				
Flowers opened	.	3	7	32	40	40	71	67	88	89	68	96	85	92	114	125	115	40	8	1,180
Bolls shed (relative)		1	4	23	23	29	61	58	77	72	53	59	40	40	44	36	51	30	5	706
Bolls shed due to boll-worms	.	1	4	17	21	24	50	50	74	65	48	44	27	16	20	15	3	..	..	479
Bolls shed due to other causes	..			6	2	5	11	8	3	7	5	15	13	24	24	21	48	30	5	227
Flowers which developed into mature bolls (relative).	..	2	3	9	17	11	10	9	11	17	15	37	45	52	70	89	64	10	3	474
Percentage of bolls to flowers	..	66·6	42·8	28·1	42·5	27·5	14·0	13·4	12·5	19·1	22·0	38·5	32·9	56·5	61·4	71·2	55·6	25·0	37·5	40·1

TABLE XIX

Flower-opening, relative success from flowers to mature bolls and shedding of bolls with causes of shedding from the caged plants and their controls

(1927-28, Surat)

—	5th November	12th November	19th November	26th November	3rd December	10th December	17th December	24th December	31st December	7th January	14th January	21st January	28th January	4th February	11th February	18th February	25th February	TOTAL
CAGED PLANTS 20.																		
Flower-opening . . .	.	23	111	205	304	448	450	523	570	409	202	63	19	6	1	..	..	3,334
Bolls shed (relative) . .	.	15	31	22	99	258	310	428	454	361	165	47	10	6	1	..	.	2,207
Flowers which developed into mature bolls (relative)	.	8	80	183	205	190	140	95	116	48	37	16	9	..	..	..	..	1,127
Percentage of bolls to flowers .	.	34·8	72·1	89·2	67·4	42·4	31·1	18·2	20·4	11·7	18·3	25·4	47·4	.	..	..	..	33·8
UNCAGED PLANTS 16																		
Flower-opening . .	.	1	6	12	31	67	67	116	142	198	279	223	221	109	46	22	2	1,542
Bolls shedding (relative) .	.	1	4	4	19	36	40	50	66	91	135	138	188	108	46	22	2	950
Bolls shed due to boll-worms .	.	1	4	3	16	23	23	31	25	24	24	10	6	2		.	.	192
Bolls shed due to other causes .	..	..	.	1	3	13	17	19	41	67	111	128	182	106	46	22	2	758
Flowers which developed into mature bolls (relative)	..	..	2	8	12	31	27	66	76	107	144	85	33	1	.	..	..	592
Percentage of bolls to flowers .	..	..	33	67	39	46	40	57	53	54	52	38	15	1	.	..	..	38·4

TABLE XX

Dates of picking of kapas *from caged and uncaged plants and the number of bolls picked each time*

Pickings	1928-29				1929-30				1930-31			
	CAGED PLANTS (99)		UNCAGED PLANTS (104)		CAGED PLANTS (113)		UNCAGED PLANTS (112)		CAGED PLANTS (118)		UNCAGED PLANTS (116)	
	Date of picking	No. of bolls picked	Date of picking	No. of bolls picked	Date of picking	No. of bolls picked	Date of picking	No. of bolls picked	Date of picking	No. of bolls picked	Date of picking	No. of bolls picked
1st picking .	7th to 9th January.	633	8th to 12th February.	1,055	1st to 2nd January.	1,023	22nd to 24th February.	1,809	5th to 6th January.	148	20th to 26th February.	5,853
2nd picking . .	18th to 22nd January.	1,943	22nd to 26th February.	3,122	28th to 29th January.	40	11th to 13th March.	4,182	14th to 24th January.	4,497	12th to 14th March.	2,180
3rd picking . .	31st January to 5th February.	3,213	5th to 7th March.	1,870	10th to 11th February.	7,976	19th March.	272	14th to 19th February.	3,107	19th March.	14
4th picking . .	18th to 22nd February.	4,078	19th to 20th March.	561	..	..	24th March.	29	10th March.	771	..	..
5th picking . .	26th to 28th February.	1,192	22nd March.	208	..	..	..	..	..	..	..	..
6th picking . .	2nd to 7th March.	110	..	..	..	..	..	..	..	..	..	..
TOTAL .	..	11,169	..	6,816	..	9,039	..	6,292	..	8,523	..	8,037

TABLE XXI

Classification of the locks collected per plant from the caged and uncaged plants during 3 years at Surat

——	No. of plants observed	Total locks	Sound locks	DAMAGED LOCKS.		USELESS LOCKS.	
				Due to boll-worms	Due to other causes	Due to boll-worms	Due to other causes
1928-29.							
Caged plants	99	350	307	13	24	3	3
Control plants	104	202	144	38	9	7	4
1929-30.							
Caged plants	113	244	236	4	2	2	..
Control plants	112	171	156	9	2	3	1
1930-31.							
Caged plants	118	223	206	14	2	1	..
Control plants	116	212	191	18	1	2	..

TABLE XXII

Population of Earias *larvae in pods of 25* bhendi *plants plucked as they became ripe on different varieties at Surat (plot un-manured)*

(1930-31)

Date	Surat 5			Surat 9			Khandesh late		
	Weight in Tolas	No. of pods	*Earias* Larvae	Weight in Tolas	No. of pods	*Earias* Larvae	Weight in Tolas	No. of pods	*Earias* Larvae
1st September 1930 . . .	..	..	..	11	12	9	..	..	..
5th September 1930 . . .	..	..	..	3	8	2	..	..	..
11th October 1930 . . .	..	..	..	..	..	..	7	4	..
23rd October 1930 . . .	..	..	..	10	16	31	35	26	12
28th October 1930 . . .	8	12	25	4	9	17	16	22	7
2nd November 1930 . . .	1	3	3	6	12	15	44	34	13
6th November 1930 . . .	..	..	..	1	2	..	..	..	..
13th November 1930 . . .	3	2	2	2	5	3	22	24	8
22nd November 1930 . . .	..	..	..	1	3	4	38	26	16
6th December 1930 . . .	11	5	1	8	14	4	17	17	2
13th December 1930 . . .	5	10	2	4	12	3	4	8	3
20th December 1930 . . .	10	14	7	2	5	..	14	25	6
31st December 1930 . . .	8	20	..	4	10	4	17	46	4
10th January 1931 . . .	26	50	5	10	37	5	36	97	4
22nd January 1931 . . .	16	24	7	17	45	5	26	46	5

TABLE XXIII

Population of Earias *larvae in pods of 25* bhendi *plants plucked as they became fully grown on different varieties at Surat (plot manured with castor-cake)*

(1930-31)

Date	SURAT 5			SURAT 9			AMERICAN LONG GREEN			AMERICAN DWARF GREEN			AMERICAN WHITE VELVET			KHANDESH LATE			REMARKS
	Tolas	Pods	*Earias* larvae	Tolas	Pods	*Earias* larvae	Tolas	Pods	*Earias* larvae	Tolas	Pods	*Earias* larvae	Tolas	Pods	*Earias* larvae	Tolas	Pods	*Earias* larvae	
23rd August 1930 .	..	..	..	7	9	1	..	..	..	..	..	..	..	..	..	..	..	..	
26th August 1930 .	..	..	..	16	20	8	..	..	..	..	..	..	..	..	..	..	..	..	
1st September 1930 .	..	..	..	30	25	23	..	..	..	..	..	..	..	..	..	..	..	..	
5th September 1930 .	8	6	3	21	20	11	2	1	..	2	2	..	1	1	..	..	..	..	
18th September 1930	25	10	12	27	24	21	..	..	..	..	..	..	2	1	1	..	..	..	
6th October 1930 .	8	8	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
11th October 1930 .	..	..	..	3	9	6	..	..	..	..	..	..	..	..	..	42	25	4	
23rd October 1930 .	56	50	94	22	35	50	..	..	..	3	3	8	..	..	..	83	45	23	
28th October 1930 .	24	35	51	9	16	25	..	..	..	..	..	..	..	..	..	17	14	9	
3rd November 1930 .	38	42	26	8	15	16	..	..	..	..	..	..	..	..	..	54	38	18	
6th November 1930 .	4	7	8	..	..	..	..	..	..	..	..	..	..	..	..	6	6	5	
13th November 1930	15	11	12	3	4	1	..	..	..	..	..	..	..	..	..	17	13	4	
22nd November 1930	17	28	14	5	16	9	..	..	..	..	..	..	..	..	..	42	31	10	
6th December 1930	27	36	8	6	16	3	16	15	5	37	38	7	19	22	5	40	34	4	
13th December 1930	17	35	4	6	17	8	2	4	1	6	15	3	4	9	3	6	14	2	
20th December 1930	31	51	10	5	17	12	10	13	4	18	27	8	13	17	8	25	45	6	
31st December 1930	40	79	6	5	19	3	8	18	1	18	38	6	16	29	5	38	84	8	
10th January 1931	50	101	6	7	24	3	18	38	8	33	62	3	7	17	8	80	151	9	
22nd January 1931	60	98	18	22	64	9	28	44	6	32	63	10	29	55	8	72	119	9	

TABLE XXIV

Population of Earias *larvae in pods of 25* bhendi *plants collected as they became ripe on different varieties, sown in July and August 1930 at Surat*

(1930-31)

Date	VARIETIES SOWN IN JULY 1930									VARIETIES SOWN IN AUGUST 1930											
	Surat 9 in ridge			Surat 9 in furrow			Khandesh late on ridge			Khandesh late in furrow			Surat 5 on ridge			Khandesh late on ridge			Khandesh late in furrow		
	Tolas	Pods	*Earias* larvae	Tolas	Pods	*Earias* larvae	Tolas	Pods	*Earias* larvae	Tolas	Pods	*Earias* larvae	Tolas	Pods	*Earias* larvae	Tolas	Pods	*Earias* larvae	Tolas	Pods	*Earias* larvae
11th October 1930	..	.	..	28	39	16	.	.	..	.	.	..	.		..		.	.	..	..	..
23rd October 1930	..	.	..	51	77	111	21	14	4	2	3	1	.		..		.	..	.	..	..
28th October 1930	..	..	..	8	18	21	9	12	5	8	7	4	7	12	21	2	4	4	..	..	..
3rd November 1930	..	..	..	6	12	12	25	26	13	9	7	6			..	4	4	3	4	2	4
6th November 1930	22	42	33	.	..	.	2	2	..	.			.		..	.	.	..	..	..	..
13th November 1930	..	..	.	2	2	3	9	10	4	12	10	2	.	.	..	2	1	1	..		..
22nd November 1930	4	10	2	4	19	13	7	7	4	6	8	3			.	1	1	..	..	..	..
6th December 1930	4	14	6	4	24	13	22	26	7	10	16	3	..	.	..	16	14	..	..	..	..
13th December 1930	2	12	8	4	10	7	3	12	4	2	7	2	.	.	.	4	6	3	4	6	3
20th December 1930	2	5	2	3	10	7	10	17	8	6	12	2	2	2	.	3	5	.	2	4	2
31st December 1930	3	9	..	2	16	7	9	22	4	8	19	2	.	..	.	6	11	2	..	..	..
10th January 1931	..	..	..	1	3	.	28	43	4	20	30	3	..	..	..	..	.	..	..	..	..
22nd January 1931	21	52	14	7	34	5	68	95	15	59	101	13	.	..		46	62	11	12	28	11

TABLE XXV

Population of Earias *larvae on 25 plants of* bhendi *of different varieties in Khandesh, dibbled with the general crop of cotton on 20th June 1930*

(1930-31. Jalgaon)

Date	Nasik local			Katai local			Surat 5			Surat 9			American long green			American dwarf green			American white velvet			Remarks
	Tolas	Pods	*Earias* larvae	Tolas	Pods	*Earias* larvae	Tolas	Pods	*Earias* larvae	Tolas	Pods	*Earias* larvae	Tolas	Pods	*Earias* larvae	Tolas	Pods	*Earias* larvae	Tolas	Pods	*Earias* larvae	
12th August 1930	74	40	.	.	.	.	.	.	.	46	27	.	.	.	.	.	.	.	.	.	..	Excellent growth of plants throughout Katai *bhendi* grew over 6 feet and the rest about 4 feet and over
20th August 1930	106	44	..	.	.	.	3	2	.	90	38	.	.	.	.	7	3	.	.	..	.	
26th August 1930	125	68	1	.	.	.	28	14	.	130	67	1	.	.	.	10	5	..	.	.	..	
30th August 1930	97	52	1	.	.	.	35	22	.	90	49	.	.	.	.	16	8	..	..	.	.	
3rd September 1930	66	52	6	.	.	.	52	32	.	100	85	14	.	.	.	3	2	1	3	6	1	
13th September 1930	38	20	1	38	17	1	163	57	3	72	47	4	.	.	.	45	19	.	44	20	.	
22nd September 1930	12	9	2	46	31	3	28	10	1	3	2	.	11	6	1	16	7	1	21	8	.	
26th September 1930	12	18	3	83	31	3	37	7	3	11	11	2	12	9	.	8	8	.	15	6	.	
30th September 1930	28	32	15	127	48	6	3	1	1	30	30	5	18	7	1	12	8	2	10	5	1	
7th October 1930	64	81	53	210	86	9	34	18	5	68	66	32	77	27	5	50	17	4	36	20	2	
13th October 1930	14	21	14	45	34	5	39	25	11	11	15	6	63	37	6	45	29	5	27	14	1	
18th October 1930	12	15	11	107	80	20	80	56	32	7	10	5	44	22	7	43	21	11	66	37	7	
23rd October 1930	7	9	10	47	31	4	22	22	13	.	.	.	35	13	8	35	20	13	99	42	14	
26th October 1930	13	25	60	75	41	40	10	10	19	5	13	18	33	16	49	41	21	41	40	24	42	
13th November 1930	..	.	..	77	58	23	5	6	10	.	.	.	43	33	41	33	21	17	42	29	22	
25th November 1930	.	.	..	48	38	21	19	17	25	1	2	3	45	31	41	72	54	78	47	41	43	
1st December 1930	..	.	..	11	12	13	6	9	13	.	.	.	29	34	47	77	64	83	33	31	41	
7th December 1930	..	.	..	11	9	6	11	16	17	.	.	.	26	24	52	51	36	47	31	28	17	
17th December 1930	..	.	..	.	.	.	.	.	.	.	.	.	19	12	21	19	17	33	21	16	32	
25th December 1930	.	.	..	14	9	12	.	.	.	.	.	.	30	18	43	38	26	42	21	17	32	
6th January 1931	..	..	..	18	19	17	7	6	14	.	.	.	14	17	28	12	16	23	19	15	9	
15th January 1931	.	..	.	11	13	11	6	7	8	.	.	.	16	18	27	18	23	43	..			

TABLE XXVI

***Population** of* Earias *larvae on* bhendi *plants of different varieties, dibbled one month after the general crop* (i.e., *on 19th July 1930 at Jalgaon*)

(1930-31)

Date	Nasik local			Katai local			Surat 5			Surat 9			American long green			American dwarf green			American white velvet			Remarks
	Tolas	Pods	*Earias* larvae	Tolas	Pods	*Earias* larvae	Tolas	Pods	*Earias* larvae	Tolas	Pods	*Earias* larvae	Tolas	Pods	*Earias* larvae	Tolas	Pods	*Earias* larvae	Tolas	Pods	*Earias* larvae	
No. of plants observed each time	25 plants			4 plants.			1 plant			Failed to grow			3 plants.			5 plants			8 plants.			
16th September 1930	13	15	..	.	.	..	..		..	..	..		.	.	.	..	..	..	..	..	..	Poor growth of plants; most of them did not grow at all.
22nd September 1930	5	10	2	..	..	..	..	..	.	..	..	..	..	..	..	.	.	..	..	..	..	
30th September 1930	11	19	1	..	.	..	5	3	2	.	..	..	..	.	..	..	..	..	..	..	..	
7th October 1930	18	13	11	6	3	..	5	2	.	.	..	..	2	1	..	..	..	..	..	..	.	
13th October 1930	12	15	3	..	..	.	1	1	.	.	..	..	..	..	..	..	..	..	..	..	..	
20th October 1930	9	11	5	11	5	1	.	.	.	.	..	..	..	..	..	4	2	..	..	..	..	
26th October 1930	1	1	1	22	14	3	..	..	..	..	.	..	..	..	..	1	1	..	2	1	1	
12th November 1930	5	12	14	6	5	13	5	6	5	..	..	..	..	..	..	7	5	4	3	1	2	
22nd November 1930	..	..	..	9	4	3	4	3	2	..	.	..	.	..	..	1	1	2	4	3	2	
5th December 1930	2	6	6	10	11	5	3	1	1	..	..	..	..	..	..	11	6	7	2	2	3	
10th December 1930	1	3	3	9	7	8	1	1	..	.	.	.	..	..	..	5	3	7	3	2	5	
16th December 1930	..	.	..	6	4	3	5	3	5	.	..	.	..	..	..	11	7	7	12	8	6	
26th December 1930	..	.	..	10	6	17	3	2	5	..	..	..	2	1	2	5	3	5	8	5	9	
6th January 1931	.		..	6	6	3	..	..	..	.	..	..	..	..	..	..	..	..	12	18	17		
16th January 1931	.		..	14	15	2	3	2	1	..	..	.	6	3	3	6	5	8	12	8	5	

TABLE XXVII

Population of Earias *larvae on* bhendi *plants, dibbled in July and August 1930 at Jalgaon*

(1930-31)

Date	Dibbled on 7th July 1930						Remarks	Date	Dibbled on 9th August 1930						Remarks
	25 plants Nasik			7 plants Katai					25 plants Nasik			25 plants Katai			
	Tolas	Pods	*Earias* larvae	Tolas	Pods	*Earias* larvae			Tolas	Pods	*Earias* larvae	Tolas	Pods	*Earias* larvae	
3rd September 1930	43	29	4	..	..	..	This plot was dibbled a fortnight after the general sowing. Germination was bad and out of 50 dibbles only 25 in one and 7 in the other could be secured for our observations.	20th October 1930	3	4	3	22	12	8	Germination was not good and the plants were very stunted in growth, being less than a foot.
16th September 1930	30	13	2	..	..	..		26th October 1930	3	5	4	17	8	5	
22nd September 1930	30	13	5	..	..	..		12th November 1930	3	5	8	52	27	22	
26th September 1930	3	4	3	..	..	..		22nd November 1930	4	8	7	50	28	13	
30th September 1930	..	..	..	5	3	..		5th December 1930	3	13	17	11	16	9	
7th October 1930	77	101	32	41	21	4		16th December 1930	1	3	2	11	8	13	
11th October 1930	11	17	4	8	7	2		25th December 1930	2	3	3	9	4	6	
20th October 1930	6	8	4	28	20	4		16th January 1931	4	4	3	5	7	3	
26th October 1930	..	.	..	22	11	5									
12th November 1930	6	11	17	9	7	10									
18th November 1930	..	..	..	5	5	2									
27th November 1930	9	17	13	23	16	5									
9th December 1930	1	3	3	3	4	5									
16th December 1930	..	..	..	11	8	13									
25th December 1930	5	10	12	5	5	2									
16th January 1931	..	..	..	6	9	7									

TABLE XXVIII

Boll-worm moths attracted to baits exposed in the cotton fields at Surat

(1927-28)

Date	Cotton seed	*Bhendi* seed	Sesamum cake
20th December 1927	Started *	..	..
23rd December 1927	8	..	..
24th December 1927	8	..	..
25th December 1927	1	..	..
30th December 1927	..*	..	..
1st January 1928	1	..	..
2nd January 1928	17	..	..
6th January 1928	1*	Started *	..
7th January 1928	..	..	..
8th January 1928	3	1	..
9th January 1928	5	..	..
10th January 1928	..*	1*	Started *
14th January 1928	..*	..*	..
17th January 1928	1	2*	..*
19th January 1928	..*	..*	..*
23rd January 1928	..*	1*	1*
24th January 1928	..	..	1
25th January 1928	..*	..*	..*
29th January 1928	..	4	11
30th January 1928	1	1	1
31st January 1928	1	3	38
1st February 1928	1*	1*	2*
2nd February 1928	3	2	8
4th February 1928	..	..	2
6th February 1928	1*	1*	1*
8th February 1928	..	2	5
9th February 1928	..	6	3
11th February 1928	..	..	1
13th February 1928	..*	..*	1*
14th February 1928	1	2	4
16th February 1928	2	1	..
17th February 1928	1	..	..

* Indicates the days on which the baits were moistened with water.

TABLE XXIX

Boll-worm moths attracted to the bait pans at Surat

(1929-30)

Week ending	Sesamum cake			Cotton seed cake			Groundnut cake		
	No. of pans	*Earias* moths	Moths of Pink boll-worm	No of pans	*Earias* moths	Moths of Pink boll-worm	No of pans	*Earias* moths	Moths of Pink boll-worm
19th October 1929	3	2	..	4	2	..	..	..	..
26th October 1929	3	1	..	4	1	..	..	..	..
2nd November 1929	3	1	..	4	.	1	..	..	..
9th November 1929	3	6	6	4	.	28	..	..	..
16th November 1929	4	8	18	8	20	34	..	..	..
23rd November 1929	4	33	22	8	43	70	..	..	..
30th November 1929	4	95	9	8	56	30	2	23	6
7th December 1929	4	16	10	8	52	25	2	15	1
14th December 1929	4	23	10	8	23	19	2	3	4
21st December 1929	4	50	7	8	46	13	2	38	7
28th December 1929	4	53	7	8	26	14	2	2	1
4th January 1930	4	14	11	8	14	23	2	5	1
11th January 1930	4	43	25	8	67	97	2	7	22
18th January 1930	4	1	4	8	6	10	2	2	..
25th January 1930	4	196	145	8	73	208	2	69	84
1st February 1930	4	90	79	8	19	114	2	17	38
8th February 1930	4	310	102	8	168	242	2	210	61
15th February 1930	5	344	255	9	201	445	3	559	164
22nd February 1930	5	189	407	9	96	620	3	63	213
1st March 1930	5	14	23	9	7	75	3	21	15

TABLE XXX

Boll-worm moths attracted at the bait pans at Surat

(1930-31)

Week ending.	Groundnut cake (2 pans)		Sesamum cake (1 pan)		Cotton seed-cake (1 pan)		Mixture of groundnut, cotton seed-cakes (2 pans)		Sandal Wood paste (1 pan)		Nutmeg paste (1 pan)		Mixture of sesamum and cotton seed-cakes (2 pans)	
	Earias moths	Moths of Pink boll-worm	*Earias* moths	Moths of Pink boll-worm	*Earias* moths	Moths of Pink boll-worm	*Earias* moths	Moths of Pink boll-worm	*Earias* moths	Moths of Pink boll-worm	*Earias* moths	Moths of Pink boll-worm	*Earias* moths	Moths of Pink boll-worm
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
11th October 1930	..	..	..	..	..	..	..	..	..	..	..	..	..	..
18th October 1930	3	..	..	..	..	..	..	..	..	..	..	..	..	..
25th October 1930	1	..	..	..	..	..	..	..	..	..	..	..	..	..
1st November 1930	7	..	6	..	1	..	..	..	6	..	16	..	..	..
8th November 1930	65	..	7	..	9	..	4	..	10	..	9	..	..	..
15th November 1930	4	17	3	5	1	13	9	13	3	1	6	5	..	..
22nd November 1930	10	65	5	14	3	42	..	38	2	..	6	5	..	..
29th November 1930	20	45	10	8	..	14	19	36	6	1	4	..	..	..
6th December 1930	14	34	15	27	1	10	7	27	1	1	1	..	..	..
13th December 1930	12	7	11	1	..	..	1	4	1	1	1	..	..	..
20th December 1930	8	6	1	2	..	2	..	4	*		..	..	..	..
27th December 1930	21	37	17	6	6	11	20	22		..	..	..	..	..
3rd January 1931	15	22	21	13	..	15	8	35		..	..	..	..	..
10th January 1931	2	14	..	4	..	3	1	13		..	..	..	..	..
17th January 1931	..	2	..	..	..	..	..	2	*	..	..	..	..	..
24th January 1931	5	36	3	34	3	24	5	34		..	..	..	..	..
31st January 1931	8	74	3	17	1	42	21	77		..	..	..	..	..
7th February 1931	31	199	46	195	..	..	..	..		..	..	..	43	169
14th February 1931	18	152	31	151	..	..	..	..		..	..	..	23	153
21st February 1931	12	67	41	89	..	..	..	..		..	..	..	19	71
28th February 1931	2	8	4	21	..	..	..	..		..	..	..	8	28

* Stopped.

TABLE XXXI

Boll-worm moths attracted at the bait pans at Jalgaon

(1929-30)

Fortnight ending	Sesamum cake (2 pans)	Cotton-seed cake (2 pans)	4 pans (2 of sesamum cake and 2 of cotton-seed cake)
	(*Earias* moths)	(*Earias* moths)	(Pink Boll-worm moths)
14th September 1929	3	..	4
28th September 1929	11	5	3
12th October 1929	75	43	126
26th October 1929	147	108	712
9th November 1929	128	124	460
23rd November 1929	201	346	1,347
7th December 1929	401	484	835
21st December 1929	109	49	269
4th January 1930	35	22	91
18th January 1930	13	17	55
1st February 1930	4	3	47
15th February 1930	..	1	5
1st March 1930	1	1	75
15th March 1930	..	..	25
29th March 1930	..	..	4

TABLE XXXII

Boll-worm moths attracted to the bait pans at Jalgaon

(1930-31)

Week ending	COTTON SEED CAKE		GROUNDNUT CAKE FREELY DILUTED IN WATER OF THE WHOLE PAN		COTTON SEED CAKE		GROUNDNUT CAKE MOISTENED IN DISH	
	Earias	Platyedra	Earias	Platyedra	Earias	Platyedra	Earias	Platyedra
11th October 1930	2	..	1	..	..	..	1	1
18th October 1930	2	..	3	1	..	..	11	5
25th October 1930	4	7	7	2	4	3	20	10
1st November 1930	2	5	2	32	12	26	11	23
8th November 1930	3	11	11	24	12	24	5	17
15th November 1930	5	19	13	117	14	51	15	41
22nd November 1930	6	47	31	367	9	157	16	128
29th November 1930	32	166	110	745	12	215	80	338
6th December 1930	20	245	197	1,161	66	993	190	210
13th December 1930	78	237	659	982	294	992	116	143
20th December 1930	21	206	191	390	181	530	64	127
27th December 1930	29	251	216	272	217	452	78	235
3rd January 1931	74	708	113	184	152	332	415	846
10th January 1931	49	770	152	129	299	313	590	843
15th January 1931	73	426	98	29	206	141	235	250

TABLE XXXIII

Weekly flower-opening, percentage of the bolls shed due to boll-worms out of the total bolls shed, number of flowers which developed into mature bolls and the percentage of the weekly flowers which succeeded into mature bolls in the control plot and in the plots dusted with calcium arsenate alone and calcium arsenate with lime.

(1926-27)

(Observations of 20 plants in each case)

Weeks	CONTROL PLOT				DUSTED WITH CALCIUM ARSENATE				DUSTED WITH CALCIUM ARSENATE AND LIME 1 : 3.			
	Flowers opened	Percentage of bolls shed due to boll-worm out of total shed	No. of flowers developed into mature bolls	Percentage success of flowers into mature bolls	Flowers opened	Percentage of bolls shed due to boll-worms out of total shed	No of flowers developed into mature bolls	Percentage success of flowers into mature bolls	Flowers opened	Percentage of bolls shed due to boll-worm out of total shed	No of flowers developed into mature bolls	Percentage success of flowers into mature bolls
4th December 1926 .	71	70 4	10	14 0	7	12 8	5	71·4	7	12 8	4	57·1
11th December 1926 .	67	74 6	9	13 4	44	20 4	28	63 6	41	46 3	16	39·1
18th December 1926 .	88	84 0	11	12 5	72	13 8	51	70 8	49	32 6	17	34·6
25th December 1926 .	89	73 0	17	19 1	193	15 0	118	61·5	107	32 7	49	45·7
1st January 1927	68	70 5	15	22 0	229	11 3	134	58 5	154	35 6	73	47·4
8th January 1927	96	45 8	37	38 5	296	8 4	98	31 0	211	26 5	112	53·4
15th January 1927 .	85	31 7	45	52 9	265	9 4	15	5 6	198	19 9	101	51 0
22nd January 1927 .	92	17 3	52	56 5	293	4 0	9	3 0	237	11 3	66	27·9
29th January 1927 .	114	17 5	70	61 4	209	1 0	6	2 8	196	7 3	31	15·8
5th February 1927 .	125	12 0	89	71 2	102	3 9	8	7 8	189	6 9	19	10·0
12th February 1927 .	115	2 6	64	55·6	33	..	8	24 2	134	4·4	8	5·9

TABLE XXXIV

Weekly flower-opening and relative number of flowers which developed into mature bolls from the dusted and control plots

(1927-28)

Treatments	—	12th November	19th November	26th November	3rd December	10th December	17th December	24th December	31st December	7th January	14th January	21st January	28th January	4th February	11th February	18th February
(1) Dusting calcium arsenate at 5 days interval.	Flowers opened	..	17	62	177	344	287	408	397	207	77	6	..	..	..	..
	Bolls matured out of above flowers.	..	10	37	123	195	60	28	5	1	..	..	..	..	..	..
(2) Dusting as above and spraying fish oil rosin soap.	Flowers opened	..	16	50	103	283*	270	315	309	219	135	88	3	..	..	..
	Bolls matured out of the above flowers.	..	10	35	64	170	100	48	16	1	1	4	..	..	..	..
(3) Dusting calcium arsenate with gram flour.	Flowers opened	1	17	44	131	290	194	251	246	258	115	42	7	..	..	..
	Bolls matured out of the above flowers.	..	9	20	62	133	80	70	31	12	11	3	1	..	..	..
(4) Dusting calcium arsenate twice at bud development and twice at flower-opening time.	Flowers opened	3	10	31	89	190	137	196	236	192	117	43	9	..	..	..
	Bolls matured out of the above flowers.	1	3	14	53	115	58	42	27	8	1	2	..	..	..	..
(5) Dusting calcium arsenate only twice at flowering time.	Flowers opened	..	..	..	13	84	93	147	289	* 335	421	286	97	11	2	..
	Bolls matured out of the above flowers.	..	..	..	13	58	73	113	135	36	20	11	8	..	1	..
(6) Untreated plot . . .	Flowers opened	..	14	37	61	108	77	112	159	165	200	157	116	55	22	8
	Bolls matured out of the above flowers.	..	4	13	22	45	37	54	76	63	60	68	47	10	2	1

* Spraying started.

TABLE XXXV

Analysis of calcium arsenate (through the courtesy of the Agricultural Chemist, College of Agriculture, Poona)

Percentage of	Berger's calcium arsenate (from England)	Calcium arsenate from Grasselli & Co. (from America)
Moisture	1·70	traces.
Sand	0·25	0·20
Soluble arsenic oxide ($As_2 O_5$)	1·26	0·22
Total arsenic oxide ($As_2 O_5$)	45·43	40·11

TABLE XXXVI

Dates of dusting in the different plots in the year 1928-29

Plot No.	Treatment given	Date of 1st dusting	Date of 2nd dusting	Date of 3rd dusting	Date of 4th dusting
1	Dusting with blackened calcium arsenate when the boll-worms are feeding in shoots.	8th October.	18th October.	29th October.	..
2	Dusting with blackened calcium arsenate when the flower-bud development is vigorous.	6th November.	15th November.	24th November.	3rd December.
3	Dusting with blackened calcium arsenate when the boll-development has commenced.	19th November.	28th November.	7th December.	17th December.
4	Dusting with white calcium arsenate alone when vigorous flower-bud development is in progress.	5th November.	16th November.	25th November.	3rd December.
5	Dusting with sodium silico-fluoride alone when the flower-bud development is in progress.	7th November.	16th November.	26th November.	5th December.
6	Dusting with blackened sodium silico-fluoride when flower-bud development is in progress.	8th November.	17th November.	27th November.	7th December.

TABLE XXXVII

Weekly flower-opening and success of flowers to mature bolls from 20 plants in each case from plots dusted with insecticides and their controls

(1928-29)

Plot No	Treatment	—	3rd November	10th November	17th November	24th November	1st December	8th December	15th December	22nd December	29th December	5th January	15th January	22nd January	29th January	2nd February
2	Blackened calcium arsenate at bud development.	Flowers opened	..	.	79	156	240	322	477	379	193	73	21	1	1	..
		Bolls matured out of the above flowers	..	.	51	85	99	125	142	59	4	.	.	.	..	..
2-A	Control for No 2 . .	Flowers opened	..	.	35	77	98	171	206	281	225	194	167	89	48	19
		Bolls matured out of the above flowers	.	.	8	16	26	56	130	142	83	34	26	5	4	..
4	White calcium arsenate at bud development.	Flowers opened	.	.	106	212	294	484	644	446	269	116	35	..	..	..
		Bolls matured out of the above flowers	..	..	58	121	161	214	225	51	11	2	.	..	..	..
4-A	Control for No 4 . .	Flowers opened	.		141	174	162	196	269	252	185	179	160	81	14	6
		Bolls matured out of the above flowers	.		38	47	48	83	150	123	76	48	29	13	1	..
6	Blackened sodium silico-fluoride at bud development.	Flowers opened	.		85	233	306	464	560	272	88	28	4	1	..	..
		Bolls matured out of the above flowers	.		49	111	110	182	221	53	4	1	.	.	.	..
6-A	Control for No. 6 . .	Flowers opened	.		51	97	109	154	228	244	178	135	108	86	34	13
		Bolls matured out of the above flowers	.	.	14	28	31	71	116	133	96	43	21	8	2	..
5	White sodium silico-fluoride at bud development.	Flowers opened		1	77	154	219	396	282	87	28	28	19	8	19	8
		Bolls matured out of the above flowers.	.	.	49	55	28	176	184	31	8	3	3	1	3	1
5-A	Control for No. 5 . .	Flowers opened	.		76	159	157	260	375	369	298	271	210	136	43	10
		Bolls matured out of the above flowers	.		27	56	56	112	202	179	104	66	41	8	5	1

TABLE XXXVIII

Weekly flower-opening and success of flowers to mature bolls from 20 plants in each case from plots dusted with insecticides and their controls

(1928-29)

Plot No.	Treatment	——	3rd November	10th November	17th November	24th November	1st December	8th December	15th December	22nd December	29th December	5th January	12th January	19th January	26th January	2nd February
1	Blackened calcium arsenate at shoot attack	Flowers opened	7	51	262	192	157	135	197	182	137	125	116	48	18	4
		Bolls matured out of the above flowers	4	9	38	38	42	40	98	106	59	44	39	9	3	..
1-A	Control for No 1 . . .	Flowers opened		3	60	120	135	237	269	317	215	175	168	72	27	5
		Bolls matured out of the above flowers		2	20	20	42	83	120	150	75	30	24	7	5	1
3	Blackened calcium arsenate at boll development.	Flowers opened .		1	85	140	170	295	462	472	293	173	69	13	..	..
		Bolls matured out of the above flowers		1	39	88	75	159	212	116	17	3	1	2	..	..
3 A	Control for No. 3 . . .	Flowers opened		.	75	110	145	226	321	299	184	139	106	58	31	..
		Bolls matured out of the above flowers	.	.	25	39	46	70	147	119	62	21	17	14	3	..

TABLE XXXIX

Dates of dusting insecticides in different plots and the total quantity of the insecticide used with the approximate cost of the poisons required

(1929-30)

Plot No.	Treatment	Date of 1st dusting	Date of 2nd dusting	Date of 3rd dusting	Date of 4th dusting	Date of 5th dusting	Total dust required calculated per acre (main insecticide only)	Approximate cost of the total insecticides used per acre
								Rs. A. P.
2	Blackened calcium arsenate at 20 lbs. mixture per acre per turn.	28th November.	9th December.	19th December.	24th December.	3rd January .	52	13 0 0
3	White calcium arsenate at 20 lbs. per acre per turn and nicotine sulphate when aphis appear.	Do.	Do.	Do.	Do.	Do.*	101	25 4 0
4	White calcium arsenate dusting at 10 lbs. per acre per dusting.	Do.	Do.	Do.	Do.	Do. .	54	13 8 0
5	Blackened sodium silico-fluoride, dusting at 40 lbs. of mixture per acre per dusting.	29th November	10th December.	25th December.	4th January .	..	111	27 12 0
6	Blackened sodium silico-fluoride at 40 lbs. mixture per acre per turn and nicotine sulphate when aphis appear.	Do.	Do.	Do.	Do.* .	..	110	27 8 0
7	White sodium silico-fluoride at 20 lbs. per acre per dusting.	Do.	Do.	Do.	Do. .	..	94	23 8 0

* With the addition of nicotine sulphate.

TABLE XL

Weekly flower-opening and success of flowers into mature bolls from 20 plants from plots dusted with insecticides and their controls

(1929-30)

Plot No.	Treatment	——	18th October	25th October	2nd November	9th November	16th November	23rd November	30th November	7th December	14th December	21st December	28th December	4th January	11th January	18th January	25th January	1st February	8th February	15th February
2	Blackened calcium arsenate at 20 lbs an acre.	Flowers opened	..	4	5	7	17	32	32	84	123	140	165	236	246	239	183	78	8	2
		Bolls matured out of the above flowers.	..	..	..	..	..	3	9	44	78	84	101	148	87	11	4	..	..	..
	Control for No. 2	Flowers opened	..	1	5	7	6	7	9	44	102	139	131	248	279	237	235	134	35	..
		Bolls matured out of the above flowers	..	.	..	..	..	.	4	17	49	74	82	175	151	53	9	10	1	..
3	White calcium arsenate at 20 lbs to an acre and nicotine sulphate when aphis appear.	Flowers opened	..	..	2	9	23	27	37	76	117	145	211	285	252	211	105	13	..	..
		Bolls matured out of the above flowers.	..	..	..	..	3	4	15	47	79	100	127	117	40	5	..	1	..	..
	Control for No 3	Flowers opened	..	4	7	17	23	27	30	80	113	133	132	170	241	222	203	92	24	2
		Bolls matured out of the above flowers	..	..	1	3	..	2	8	36	49	64	80	120	135	46	9	3	2	..
4	White calcium arsenate at 10 lbs. to an acre.	Flowers opened	..	5	3	5	19	33	27	41	114	121	166	212	307	190	178	58	8	..
		Bolls matured out of the above flowers.	..	..	..	..	..	6	8	28	85	69	90	94	99	18	1	..	..	..
	Control for plot No. 4	Flowers opened	..	..	1	6	24	21	33	64	101	118	156	223	237	208	126	44	10	3
		Bolls matured out of the above flowers.	..	..	..	..	1	3	6	36	65	63	103	125	90	24	2	..	1	..

TABLE XL—*concld.*

Weekly flower-opening and success of flowers into mature bolls from 20 plants from plots dusted with insecticides and their controls—concld.

(1929-30—*concld.*)

Plot No.	Treatment	——	18th October	25th October	2nd November	9th November	16th November	23rd November	30th November	7th December	14th December	21st December	28th December	4th January	11th January	18th January	25th January	1st February	8th February	15th February
5	Blackened sodium silicofluoride at 40 lbs. mixture per acre.	Flowers opened	..	..	1	10	13	23	38	52	119	155	153	231	308	219	149	44	3	..
		Bolls matured out of the above flowers	..	..	..	1	.	3	10	34	88	93	81	133	96	12	1	.	.	..
	Control for No 5 . .	Flowers opened .	..	3	.	4	16	27	26	55	106	143	141	200	235	217	142	64	22	1
		Bolls matured out of the above flowers.	..	.		.	1	6	10	21	51	79	75	130	101	35	11	3	..	..
6	Blackened sodium silicofluoride at 40 lbs. mixture per acre and nicotine sulphate when aphis appear.	Flowers opened .		2	5	2	12	13	19	69	130	150	140	265	315	172	85	27	2	..
		Bolls matured out of the above flowers	.	..	1	.	..	6	9	50	88	88	66	111	82	19	1	..	..	..
	Control for No 6 .	Flowers opened	..	2	3	6	19	21	32	73	111	113	136	200	240	249	144	89	24	7
		Bolls matured out of the above flowers.	..	.		.	1	6	12	30	61	64	79	135	108	54	8	3	..	..
7	White sodium silicofluoride at 20 lbs per acre.	Flowers opened .	.	3	6	10	12	17	20	60	136	193	179	298	374	191	93	18	1	1
		Bolls matured out of the above flowers	..	..	.	1	2	5	8	43	108	112	97	131	71	4	..	..	..	..
	Control for No. 7 . .	Flowers opened .	..	..	..	5	15	23	29	61	126	167	148	213	291	171	70	16	1	..
		Bolls matured out of the above flowers.	..		.	.	4		8	30	94	110	74	87	65	21	2	.	..	..

TABLE XLI

Population of Earias *larvae on weeds at Surat in 1928-29*

Week ending	*Hibiscus rugosus*		*Hibiscus manihot*		*Abutilon graveolens*		*Abutilon indicum*	
	No of plants examined	No of larvae	No. of plants examined	No of larvae	No of plants examined	No of larvae	No of plants examined	No. of larvae
14th July 1928	300	..	..	..	30	..	..	..
21st July 1928	500	..	..	..	125	..	..	..
28th July 1928	1,000	1	275	..	140	..	.	..
4th August 1928	850		200	..	150	..	.	..
11th August 1928	1,100		250	.	215	1	60	..
18th August 1928	..	.	110	.	90	5	45	..
25th August 1928	600	3	20	..	40	..	..	..
1st September 1928	200	1	..	..	50	7	..	..
8th September 1928	150	..	..		50	..	..	..
15th September 1928	200	..	..	..	..	..	45	..
22nd September 1928	100	..	40	..	..	..	..	..
29th September 1928	150	..	50	..	..	..	24	29
6th October 1928	50	..	50	40	..	..	7	36
13th October 1928	60	..	55	65	..	..	5	75
20th October 1928	80	12	9	13	.	..	2	14
27th October 1928	..	.	5	35	..	..	2	9
3rd November 1928	200 pods.	11	10	21	..	..	..	
10th November 1928	100 pods.	7	10	20	..	..	..	.

TABLE XLII

Population of Earias *larvae on weeds at Surat in 1929-30*

Week ending	*Hibiscus rugosus*		*Hibiscus manihot*		*Hibiscus ficulneous*		*Hibiscus pandurae – formis*		*Abutilon graveolens*		*Abutilon indicum*	
	Plants examined	No of larvae	Plants examined	No. of larvae	Plants examined	No of larvae	Plants examined	No. of larvae	Plants examined	No. of larvae	Plants examined	No. of larvae
6th July 1929	..	.	..	..	.	..	..	..	25	..	..	..
13th July 1929	450		.	..	..	..	..	..	25	..	..	..
20th July 1929	700	..	.	..	..	..	..	..	25	..	..	..
27th July 1929	500	..	100	..	..	..	..	..	44	..	20	..
3rd August 1929	500	..	..	..	..	..	..	..	20	..	..	..
10th August 1929	500	..	50	..	..	..	..	..	..	..	25	..
17th August 1929	500	..	25	..	15	..	25	..	25	..	25	..
24th August 1929	500	..	25	..	8	.	30	..	20	..	5	..
31st August 1929	450	..	25	..	5	..	25	..	11	..	5	..
7th September 1929	250	3	50	..	3	..	10	..	8	1	8	3
14th September 1929	100	2	50	..	..	..	15	..	10	3	3	..
21st September 1929	100	..	50	2	..	..	10	..	10	17	10	27
28th September 1929	100	1	33	18	5	..	10	8	11	7	3	20
5th October 1929	75	..	25	3	2	..	10	4	10	..	3	..
12th October 1929	60	..	25	15	..	..	10	9	5	..	4	2
19th October 1929	75	11	16	7	..	..	10	21	7	12	3	2
26th October 1929	..	..	..	..	..	..	..	..	..	..	..	..
2nd November 1929	50	8	10	25	1	..	10	6	5	13	3	3
9th November 1929	10	4	7	2	..	..	..	..	4	16	3	25
16th November 1929	10	4	6	..	..	..	10	3	..	..	3	..

TABLE XLIII

Population of Earias *larvae on weeds at Surat in 1930-31*

Week ending	*Hibiscus rugosus*		*Hibiscus manihot*		*Hibiscus ficulneous*		*Hibiscus pandurae —formis*		*Abutilon graveolens*		*Abutilon indicum*	
	Plants examined	No. of larvae	Plants examined	No of larvae	Pods	No. of larvae	Pods	Larvae	Pods	Larvae	Pods	Larvae
3rd July 1930	..	..	..	..	..	..	..	..	..	..	..	..
10th July 1930	..	..	..	..	..	..	..	..	..	..	..	..
17th July 1930	..	..	..	..	..	..	..	..	..	..	..	..
24th July 1930	..	..	..	..	..	..	..	..	..	..	..	..
31st July 1930	50	..	25	..	..	..	..	..	..	..	..	..
7th August 1930	..	..	..	..	..	..	..	..	..	..	..	..
15th August 1930	50	..	13	..	..	..	..	..	..	..	..	..
22nd August 1930	75	..	30	..	..	..	..	..	..	..	..	..
29th August 1930	110	..	30	..	..	..	..	..	..	..	..	..
5th September 1930	103	..	25	..	..	..	..	..	..	..	100	19
12th September 1930	50	..	30	..	..	..	..	..	..	..	16	1
19th September 1930	47	..	10	..	..	..	..	..	..	..	67	13
26th September 1930	123 pods.	2	10	4	..	..	..	..	14	4	..	..
3rd October 1930	181	5	10	10	..	..	20	1	..	..	104	25
10th October 1930	139	..	10	49	26	1	5	2	50	27	54	16
17th October 1930	225	2	10	4	55	6	25	6	250	48	150	18
24th October 1930	118	4	15	21	105	20	19	1	231	30	106	24
31st October 1930	50	1	25 pods.	12	30	5	58	6	100	29	60	11
7th November 1930	63	6	14	22	96	11	63	13	123	26	90	9
14th November 1930	20	..	25	10	67	18	76	7	200	100	63	4
21st November 1930	..	..	..	..	10	..	126	5	163	10	66	7
28th November 1930	..	..	32	12	50	..	86	17	125	16	90	4

TABLE XLIV

Population of Earias *larvae on plants of* Abutilon indicum *examined on the 15th of October 1927*

(A case of very heavy attack)

No. of affected pods	Larvae found in each form	Total larvae found
78	1	78
21	2	42
7	3	21
1	4	4
Total . 107	..	145

TABLE XLV

Population of Earias *larvae on* Abutilon *during summer*

(Plants found in gardens of Surat)

Date	No. of plants	No. of pods	Total Earias
20th April 1929	7	36	5
27th April 1929	28	122	19
4th May 1929	12	9	2
11th May 1929	..	..	..
18th May 1929	25	34	9
25th May 1929	25	107	23
1st June 1929	15	11	2
8th June 1929	25	175	64
15th June 1929	25	67	28
22nd June 1929	25	71	8
29th June 1929	25	33	4
6th July 1929	25	..	..
13th July 1929	25	41	..
20th July 1929	25	..	..
27th July 1929	64	2	..

TABLE XLVI

Population of Earias *larvae on* bhendi *plants* (Hibiscus esculentus) *in summer* (*1928-29*)

Date	No. of plants	Earias worms
25th April 1928	100	36
3rd May 1928	100	81
11th May 1928	100	74
16th May 1928	100	54
22nd May 1928	100	136
2nd June 1928	100	303
5th June 1928	100	126
12th June 1928	100	116
19th June 1928	100	95
27th June 1928	75	19
30th June 1928	50	50
4th July 1928	100	33
10th July 1928	100	23
17th July 1928	100	8
23rd July 1928	200	7
30th July 1928	200	65

TABLE XLVII

Population of Earias *larvae on sprouts of standing cotton sticks at Surat*

(50 plants each time)

Weeks	1928-29 SEASON			Weeks	1929-30 SEASON		
	No. of buds	No. of bolls	Total Earias		No. of buds	No. of bolls	Total Earias
2nd March 1929 .	..	832	112	8th March 1930 .	..	668	26
9th March 1929 .	..	350	56	15th March 1930 .	..	134	8
16th March 1929 .	10	70	34	22nd March 1930 .	..	26	2
23rd March 1929 .	34	20	8	29th March 1930 .	..	6	..
30th March 1929 .	75	2	2	5th April 1930 .	16	..	1
6th April 1929 . .	293	4	14	12th April 1930 .	43	1	6
13th April 1929 . .	319	16	27	19th April 1930 .	198	3	9
20th April 1929 . .	554	26	33	26th April 1930 .	263	6	16
27th April 1929 . .	469	39	57	3rd May 1930 .	323	10	27
4th May 1929 . .	310	44	76	10th May 1930 .	395	19	11
11th May 1929 . .	337	26	41	17th May 1930 .	591	49	30
18th May 1929 . .	354	21	36	24th May 1930 .	628	86	8
25th May 1929 . .	231	17	25	31st May 1930 .	620	243	22
1st June 1929 . .	467	54	48				

TABLE XLVIII

Weekly flower-opening, success of weekly flowers into bolls, and shedding of bolls due to boll-worms from the ratoon crop and also from the new crop of cotton

(1928-29)

(10 plants in each case)

	6th October	13th October	20th October	27th October	3rd November	10th November	17th November	24th November	1st December	8th December	15th December	22nd December	29th December	5th January	12th January	19th January	26th January	2nd February	9th February	16th February	23rd February	Total
Ratoon crop.																						
Flower opening . .	48	50	..	..	..	..	9	3	1	5	14	19	17	15	15	8	17	5	3	2	3	234
Bolls matured from the above flowers.	1	..	..	..	..	..	1	..	..	1	3	3	8	4	3	3	5	3	2	2	3	42
Boll shedding (Total) .	..	74	15	2	..	1	4	6	5	3	4	10	10	10	12	11	6	5	5	9	..	192
Bolls shed due to boll-worms.	..	70	15	2	..	1	4	6	5	1	3	8	4	6	1	..	2	2	3	3	..	136
New crop of 1928-29.																						
Flower opening . .	..	..	..	..	..	..	26	39	59	67	108	97	69	40	27	11	3	2	..	..	..	548
Bolls matured from the above flowers.	..	..	..	..	..	..	13	13	22	37	64	48	19	4	4	3	1	..	..	..	..	228
Boll shedding (Total) .	..	..	..	..	..	..	2	13	15	30	40	31	33	38	50	36	23	6	2	1	..	320
Bolls shed due to boll-worms.	..	..	..	..	..	..	2	10	13	24	22	12	6	6	3	3	1	..	..	..	..	102

TABLE XLIX

Population of Earias *larvae on the sprouts from cotton stumps from the Government Farm and cultivators' area till the sowing of the new crops of 1928-29*

Date	Cultivators' fields		Farm area	
	Sprouts examined	No. of larvae	Sprouts examined	No. of larvae
10th May 1928	75	*Nil*	..	..
19th May 1928	75	1	..	..
25th May 1928	75	1	..	..
1st June 1928	100	*Nil*	100	2
7th June 1928	200	1	200	1
15th June 1928	200	3	200	*Nil*
22nd June 1928	200	2	200	4
30th June 1928	200	1	200	9
9th July 1928	200	*Nil*	200	2
11th July 1928	250	2	..	..
20th July 1928	200	8	500	14
31st July 1928	200	6	200	6
11th August 1928	200	3	400	1
15th August 1928	200	15	..	..
23rd August 1928	200	29	..	..
31st August 1928	200	13	..	..
5th September 1928	200	13	..	..

TABLE L

Population of Earias *larvae on the sprouts from the cotton stumps from the cultivators' area till the sowing of the new crops of 1929-30*

KOSAD AREA			PIPLOD AREA		
Date	No. of stumps from which sprouts were collected	No. of *Earias* larvae	Date	No. of stumps from which sprouts were collected	No. of *Earias* larvae
16th May 1929	100	11	4th May 1929 .	100	..
21st May 1929 .	100	.	11th May 1929 .	100	2
30th May 1929 .	75	1	18th May 1929 .	100	..
1st June 1929 .	100	8	25th May 1929 .	200	2
8th June 1929 .	55	..	1st June 1929 .	200	5
14th June 1929 .	100	..	12th June 1929 .	200	1
28th June 1929 .	150	..	22nd June 1929 .	200	..
6th July 1929 .	200	1	27th June 1929 .	200	..
27th July 1929 .	100	..	6th July 1929 .	200	3
7th September 1929.	100	7	18th July 1929 .	200	2
20th September 1929	100	..	25th July 1929 .	200	1
			3rd August 1929 .	200	..
			10th August 1929 .	200	2
			17th August 1929 .	150	2
			25th August 1929	100	3
			6th September 1929	100	3
			14th September 1929	50	5

APPENDIX II

INDIAN CENTRAL COTTON COMMITTEE, TECHNOLOGICAL LABORATORY

SPINNING TEST REPORTS

1929-30 crop

Spinning Test Report No. 151.—Two Samples of Surat 1027 A. L. F. submitted by the Cotton Entomologist, Surat

Sample No.	Cotton	Season	Weight
			Lb.
774	1027 A. L. F., sample A	1929-30	10
775	1027 A. L. F., sample B	1929-30	8½

I. Grader's Report

	CAGED PLANTS	CONTROL PLANTS
	Sample A	Sample B
Contract valued under	Broach . . .	Broach.
Class	Extra superfine . .	Extra superfine.
Colour	White	White.
Staple length	Full 1⅛ inch . .	1⅛ inch.
Staple strength	Good	Good.
Regularity	Good	Poor.
Valued above or below contract rate .	Rs. 150 on . . .	Rs. 120 on.
Basis	Rs. 200 . .	Rs. 200.
Date of valuation	11th July 1930 . .	11th July 1930.
Remarks	....	....

II. Fibre Particulars

Mean group-length in eighth of an inch	Percentage	
	Sample A	Sample B
1. Fibre-length Distribution (Balls Sorter)—		
3	0	0·1
4	1·4	1·8
5	2·4	3·6
6	4·8	7·1
7	8·9	17·9
8	17·2	32·1
9	30·9	25·7
10	24·4	10·0
11	7·6	0·7
12	2·4	0
2. Fibre-length (inch)—		
(*a*) By Balls Sorter	1·10	0·99
(*b*) By Baer Sorter	1·07	1·03
3. Fibre-weight per inch (Millionth of an ounce)	0·202	0·167

III. Spinning Tests

1. *Treatment.*—These cottons were passed through the Porcupine Crighton (once only), Hopper, Scutcher (3 times), Card, Drawing (2 heads), Slubber, Inter, Rover, and spun from single hank roving in Ring Frame No. 1.

2. *Spinning Master's Report—*

Sample A.—The cotton is white; bright; perfectly clean; has a good feel; fairly well-ginned (seems to be 'Charkha' ginned). The staple is fine, fairly regular and strong.

Sample B.—The cotton is white; perfectly clean; bright; well-ginned; has a good soft feel. The staple is fine, regular and strong.

3. *Spinning Test details and results.*—See table appended.

IV. Remarks

Fibre.—Sample A is 7 per cent longer, but 21 per cent coarser than Sample B.

Waste.—Both samples gave low blow-room losses. Their card room losses were about normal.

Breakages.—Yarn breakages in the ring frame were comparatively few in all cases.

Yarns.—Both samples give "even" 20's and "fairly even" 34's. All the yarns are fairly free from nep. From the yarn-strength results these cottons are adjudged suitable for the following highest standard warp counts :—

Sample No.	Cotton	Highest standard warp counts
774	1027 A. L. F. Sample A	33's
775	1027 A. L. F. Sample B	37's

Conclusion.—The lint from the caged plants, though possessing a somewhat longer staple, is decidedly coarser and rather inferior in spinning performance to the lint from the control plants.

(Sd.) A. JAMES TURNER,
Director, Technological Laboratory.

Dated the 30th August 1930.

INDIAN CENTRAL COTTON COMMITTEE, TECHNOLOGICAL LABORATORY

Spinning Test Report No. 236. Samples of Surat cotton submitted by the Cotton Physiologist, Surat

Sample No.	Cotton	Season	Gross Weight
			Lbs.
1099	Protected plants	1930-31	14¼
1100	Unprotected plants	1930-31	15¼

I. Grader's Report

	Protected plants	Unprotected plants
Contract valued under	Broach	Broach.
Class	Extra superfine	Extra superfine
Colour	Creamy	Creamy
Staple length	$1\frac{1}{16}$″	$1\frac{1}{16}$″.
Staple strength	Good	Good.
Regularity	Fair	Fair.
Value above or below contract rate	Rs 70 on	Rs 75 on.
Basis	Rs 185	Rs 185
Date of valuation	25th July 1931	25th July 1931.
Remarks		

II. Fibre Particulars

Mean group-length in eighth of an inch	Percentage.	
	Protected plants	Unprotected plants
1. Fibre-length Distribution (Balls Sorter)—		
3	1·5	0 6
4	2·6	1·4
5	3 3	2·8
6	7·0	6·3
7	15·1	13·5
8	28·1	31·8
9	25·8	32·9
10	12·9	9·3
11	3·7	1·4
2. Fibre-length (inch)—		
(*a*) By Balls Sorter	1·01	1·02
(*b*) By Baer Sorter	1·02	0·99
3. Fibre-weight per inch (millionth of an ounce)	0·192	0·184

III. Spinning Tests

1. *Treatment.*— All these cottons were passed through the Porcupine, Crighton (once only), Hopper, Scutcher (3 times), Card, Drawing (2 heads), Slubber, Inter, Rover, and Spun from single bank roving in ring frame No. 1.

2. *Spinning Master's Report*—

Protected plants.—The cotton is white in colour; bright; perfectly clean; has a soft silky feel; very well-ginned. The card sliver is clean; web good and ten flat strips weigh 9·7 grams.

Unprotected plants.—The cotton is white in colour; bright; perfectly clean; has good soft feel; well-ginned. The card sliver is clean; web even; nep-free; and of a nice tension and ten flat strips weigh 11·2 grams.

3. *Spinning Test Details and Results.*—See table appended.

IV. Remarks

Fibre.—Sample Nos. 1099 and 1100 are slightly longer than 1027 A. L. F. (spaced 3′×3′: Physiological section). The fibre weight per inch of these two samples is the same as that of 1027 A. L. F.

Waste.—The cottons were picked in a very clean condition and gave a low blow-room loss. The card-room loss was normal in each case.

Breakages

Yarns.—The cottons gave "even to fairly even" 30's, but the yarns of lint from protected plants are slightly less even in the higher count. The yarns given by the lint from the protected and unprotected plants are slightly neppy. From the yarn-strength results, these cottons are adjudged suitable for the following highest warp standard counts:

Sample No.	Cotton	Counts
1099	Protected plants	33's
1100	Unprotected plants	35's

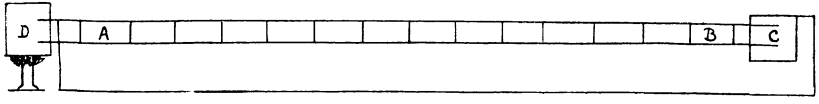
Conclusions.—It is noteworthy that the lint from the unprotected plants gave yarns which are stronger than those from the protected plants. There is very little variation in the spinning value of these two samples as compared with the last year's results.

(Sd.) N. AHMAD,
Director, Technological Laboratory.

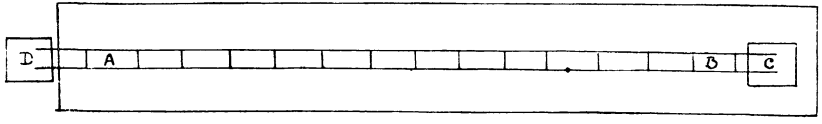
Dated, 13th August 1931.

MULTIPLE TEMPERATURE INCUBATOR.

SECTION



PLAN



Scale :- 3/8 = 1'

Plan and section of a multiple temperature incubator

APPENDIX III

DESCRIPTION OF THE MULTIPLE TEMPERATURE INCUBATOR

A device for securing different ranges of fixed temperature, higher as well as lower than the surrounding air, is described in the Technical Bulletin No. 38 of the Ministry of Agriculture, Egypt. The principle underlined in the device is, that when the two ends of a column of metal are maintained at two constant temperatures, various intermediate temperatures can be recorded at different points in the intervening space of the metal.

We felt the necessity of an instrument which would enable us to study the life of the boll-worms under varying temperatures, which are experienced during the different parts of the season. We, therefore, utilised the suggestion from the above Bulletin and prepared a Multiple Temperature Incubator, the construction and the working of which has been described below :—

Construction

Copper sheets $\frac{1}{8}$ inch in thickness were purchased and a trough (A-B), 16 feet in length 6 inches in height and 4 inches in breadth was prepared. One end of this trough was inserted into the copper tank (C), projecting 9 inches into it. The copper tank was one foot square. The other end projected two inches into another copper tank (D), which was two inches more in height than the above one (C). The whole length of the trough and the tank were placed in a rectangle wooden box one foot six inches in height and two feet four inches in width. Insulation was provided for the trough by placing an inch of layer of *kapas* round it and the remaining part of the box was filled in with saw dust. (Plate XXI).

The trough was divided into fifteen compartments (with wooden partitions) of one foot each with a separate cover for each. The covers were made up of four layers, two of which consisted of wooden planks $\frac{1}{4}$ inch in thickness and the other two of asbestos and felt respectively. Asbestos was sandwiched between the two wooden planks and the felt was struck to the bottom of the lower one. Holes were bored in the covers to accommodate the thermometers for reading the temperature in each one of the compartments.

Working

The tank (D) is filled with water which is continuously kept boiling. The tank C at the other end contains ice-cold water, temperature being maintained by continuous addition of ice. Thus the two ends of the trough (A and B) are kept at constant temperatures. A temperature gradient is thus set up between the two ends, giving different intermediate temperatures from one end to the other.

It takes about six hours to get regulated temperatures after the heating of the water is started and ice is placed in the other tank.

Absolute constant temperatures are not available but the diurnal variation in each of the compartment does not generally exceed four degrees Fahrenheit and is good enough for all purposes where greater regulation of the temperature is not necessary.

Ranges of temperature available in the twelve compartments beginning from the cold end are given below :—

Compartments	1	2	3	4	5	6	7	8	9	10	11	12
Range of temp. in F.	58	66	73	79	80	84	89	90	96	100	110	122
	to	to	to	to	to	to	to	to	to	to	to	to
	64	70	75	81	83	86	91	93	98	102	112	125

APPENDIX IV

SPOTTED BOLL-WORMS IN KHANDESH

A considerable amount of information, which was collected mostly during 1928 and 1929 in Gujarat, showed that the Spotted Boll-worms did not aestivate and that they passed their period between two cotton-growing seasons (roughly from April to August) on the fresh growth from the cotton plants and their stumps in the general cotton area, and also on *bhendi* (*Hibiscus esculentus*), which was found growing in stray irrigated plots.

As regards Khandesh, it was known that the cotton crop of that district also was affected by the Spotted Boll-worms, but exact information about the incidence of this pest in that locality was not available, and knowledge about the means of carry-over of this pest in that tract, from one season to another was particularly lacking.

In Khandesh, the cotton crop is sown in June or in July with the earliest showers of rain, and the crop is ready in October or November in normal years. During exceptional seasons, however, the crop extends up to January, if heavy late rains are received. Thus there is a span of at least six months between the two cotton crops and the summer climate being rigorous and the soil not being very highly retentive of moisture, the conditions are not very favourable for resprouting of cotton plants after the end of the season. It was, therefore, necessary to study the sources of food of this pest in that tract during the off season, and to locate the source of fresh infection to the new crop of cotton. A few observations were, therefore, made from August 1929 to January 1931 in Khandesh. Mr. Nadkarny, the junior author, was in sole charge of this work.

Incidence of Spotted Boll-worms during 1929 and 1930

During 1929 the sowing of cotton on the Government farm at Jalgaon (East Khandesh) was done in the second week of June. The flower-bud formation commenced by the beginning of August, and it was about that time that the presence of Spotted Boll-worms was first noticed in the cotton fields during that season. The flower-bud formation increased very rapidly during the month of August and flower opening began by the last week of the same month. In spite of the large number of flower-buds and bolls, the population of these worms continued to be meagre in the cotton fields, till the beginning of October, when it suddenly increased and by the second week of October as many as 84 larvae were recorded on 100 plants of cotton. By this time, however, the first picking of cotton was ready and hence the cotton crop of that season practically escaped a serious damage.

TABLE I

Weekly population of Earias *larvae on 100 plants of cotton from Government Farm at Jalgaon, 1929*

Week ending dates	Flower-buds	Bolls	Larvae in flower-buds	Larvae in bolls	Total larvae	REMARKS
3rd August 1929	263	..	1	..	1	
10th August 1929	564	..	1	..	1	
17th August 1929	990	..	1	..	1	
24th August 1929	1,312	49	2	1	3	
31st August 1929	1,487	149	5	1	6	
7th September 1929	1,099	270	..	1	1	
14th September 1929	1,055	305	1	2	3	
21st September 1929	718	622	3	3	6	
28th September 1929	423	774	4	14	18	
5th October 1929	102	734	2	69	71	
12th October 1929	30	488	6	78	84	First picking of *kapas*.
19th October 1929	..	210	..	42	42	
26th October 1929	2	100	..	11	11	Second picking.
2nd November 1929	..	55	..	7	7	
9th November 1929	..	23	..	3	3	
16th November 1929	9	6	..	1	1	Third picking.

It has been a practice in Khandesh to grow a few rows of *bhendi* (*Hibiscus esculentus*) along with cotton. Population of *Earias* larvae on these plants also was recorded by examining 15 plants of *bhendi*, collected from the cotton fields, once in a week.

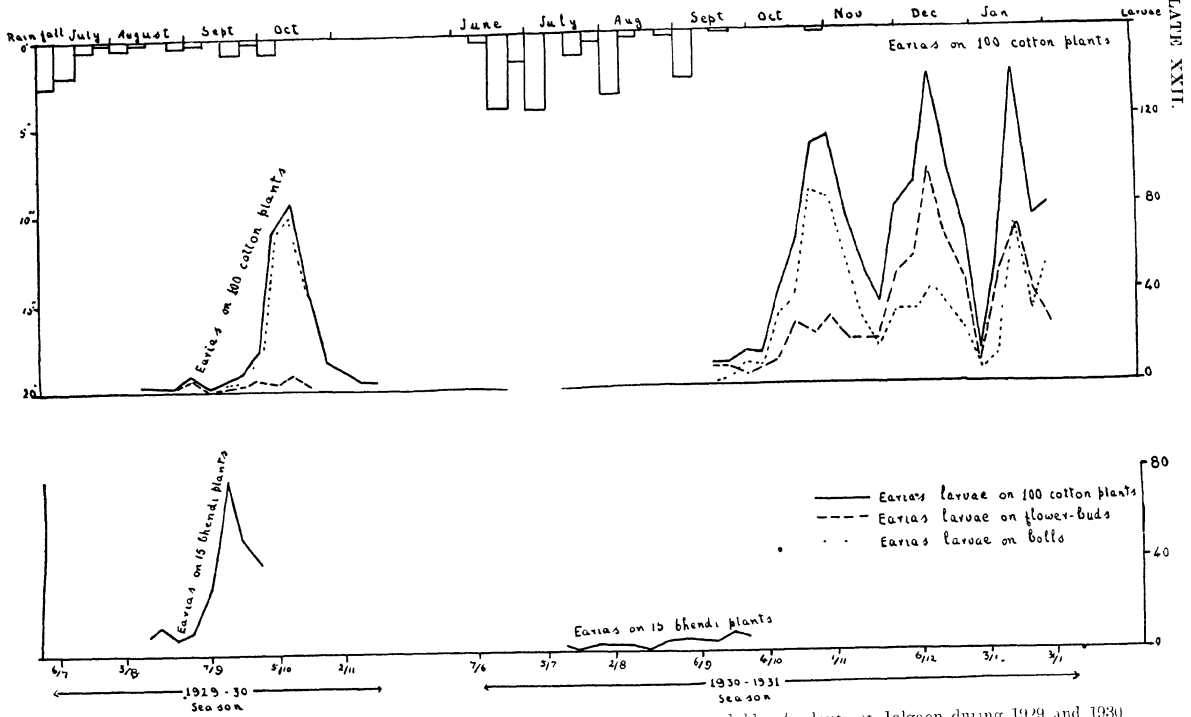
TABLE II

Earias population on 15 plants of bhendi *at Jalgaon*

1929

Weeks.	No. of flower-buds	No. of pods	Total No. of larvae	REMARKS
17th August 1929	181	36	12	
24th August 1929	135	82	7	
31st August 1929	40	104	10	
7th September 1929	8	59	29	
14th September 1929	..	55	79	
21st September 1929	..	39	51	
28th September 1929	25	58	41	Plants began to dry up.

PLATE XXII.



Showing weekly rainfall and periodical population of *Earias* larvae on cotton and *bhendi* plants at Jalgaon during 1929 and 1930

It is seen that comparatively a very much larger population of *Earias* larvae was present on 15 plants of *bhendi* than what was found on 100 cotton plants during the months of August and September. However, as soon as the *bhendi* plants dried up, the population on cotton suddenly increased, indicating thereby that the Spotted Boll-worms from *bhendi* plants diverted their attention to the flower-buds and bolls of cotton as soon as they were liberated from *bhendi* plants. (Plate XXII).

The vegetative shoots of cotton are not destroyed by this pest in Khandesh because the flower-buds on these plants are available very early ; and besides the shoots of neglectum cottons are thin and woody and are not therefore as inviting to these worms as the succulent shoots of herbacium cottons.

During the next season both cotton and *bhendi* were sown at Jalgaon in the third week of June. The earliest population of *Earias* larvae was noticed in the shoots of *bhendi* plants by the middle of July. It did not, however, increase on these plants during the month of September in this season, chiefly because it was controlled by heavy rains during the first fortnight of that month. Consequently a sudden increase of *Earias* larvae on cotton plants at the end of the *bhendi* crop was not noticed.

TABLE III

Population of Earias *larvae on 15 plants of* bhendi *from Government Farm, Jalgaon, 1930*

Weeks	No. of pods	No. of larvae	REMARKS
5th July 1930	..	..	
12th July 1930	..	1	In shoot.
19th July 1930	..	..	
26th July 1930	..	1	In shoot.
2nd August 1930	..	1	Do.
9th August 1930	54	1	
16th August 1930	51	*Nil*	
23rd August 1930	73	3	
30th August 1930	61	4	
6th September 1930	44	4	
13th September 1930	27	3	
20th September 1930	81	6	
27th September 1930	19	5	

The population of Spotted Boll-worms on cotton gradually increased and reached its maximum at the end of October. Due to heavy rains in the month of September (Table XVII of this appendix) the cotton crop of this season was delayed and therefore a good number of flower-buds and bolls were available on these plants till the month of January. The damage caused by the Spotted Boll-worms to these forms continued during all this period and hence the cotton crop of this year suffered a heavier loss than the crop of the previous season.

TABLE IV

Weekly population of Earias *larvae on 100 plants of cotton from the Government Farm at Jalgaon*

1930-31

Week ending dates	Total flower-buds	Total bolls	Larvae in flower-buds	Larvae in bolls	Total larvae
9th August 1930	24	..	..	..	..
16th August 1930	50	..	..	..	..
23rd August 1930	80	..	..	..	..
30th August 1930	378	..	..	..	..
6th September 1930	367	5	..	..	..
13th September 1930	1,171	90	8	1	9
20th September 1930	540	170	8	2	10
27th September 1930	445	685	4	9	13
4th October 1930	289	499	6	7	13
11th October 1930	300	585	12	29	41
18th October 1930	497	458	27	38	65
25th October 1930	213	576	21	87	108
1st November 1930	205	458	29	84	113
8th November 1930	199	315	19	58	77
15th November 1930	336	154	20	31	51
22nd November 1930	360	170	19	16	35
29th November 1930	538	154	46	32	78
6th December 1930	430	145	58	32	90
13th December 1930	823	131	97	43	140
20th December 1930	503	103	67	33	100
27th December 1930	515	141	47	23	70
3rd January 1931	456	80	7	6	13
10th January 1931	622	140	47	13	60
17th January 1931	800	344	69	72	141
24th January 1931	926	338	44	31	75
31st January 1931	781	496	26	55	81

The first picking of cotton was delayed till the end of October and the last was finished by the middle of December.

These observations show that the population of the Spotted Boll-worms in Khandesh first appears on the monsoon crop of *bhendi* and it rapidly increases on these plants during the months of August and September, if it is not checked by rains. As soon as the *bhendi* plants finish their life, all the moths concentrate on the cotton plants and damage the crop until it is over. This crop escapes a severe damage if it matures quickly before the pest increases on it. The pickings of cotton in Khandesh usually begin sometime during October or November and the last picking is over before the end of December but in some years it is delayed till the month of February.

TABLE V

Dates of picking kapas *on Government Farm at Jalgaon*

Year	Dates of first picking	Dates of second picking	Dates of third picking
1921	29th October . .	23rd November .	16th December.
1922	3rd November .	16th December .	9th February.
1923	18th November .	13th December .	6th January.
1924	20th October . .	20th November .	26th December.
1925	23rd October . .	6th November .	11th December.
1926	4th November .	9th December .	2nd January.
1927	21st October . .	18th November .	16th January.
1928	5th November .	19th November .	.
1929	11th October . .	25th October . .	15th November.

ESTIMATE OF DAMAGE TO THE COTTON CROP

Fifty cotton plants were kept under observation both during 1929 and 1930 for recording the flower opening and for examining the shed bolls.

TABLE VI

Flower opening and shedding of bolls from 50 plants at Jalgaon during 1929 and 1930

Year	Total flowers opened	Total bolls shed	Bolls shed due to boll-worms	Percentage bolls shed due to boll-worms
1929	651	353	54	15·3
1930	621	277	147	53·0

It was found that in 1929 only about 15 per cent of the shed bolls showed injury caused by the Spotted Boll-worms, whereas during 1930 fifty-three per cent of the shed bolls indicated boll-worm damage (Plate XXIII).

In addition to these observations, 100 plants of cotton were grown by night-caging at Jalgaon during 1930. The caging work at Jalgaon was found to be rather difficult because the plants had to be spaced very close according to the local method and there could not be sufficient room between the plants and the curtains. It was particularly difficult to keep off the Pink Boll-worm moths, which remained hidden by the side of clods or in partially opened bolls and laid their eggs on the caged plants.

TABLE VII

Yield of kapas *from the caged plants and their controls at Jalgaon in 1930*

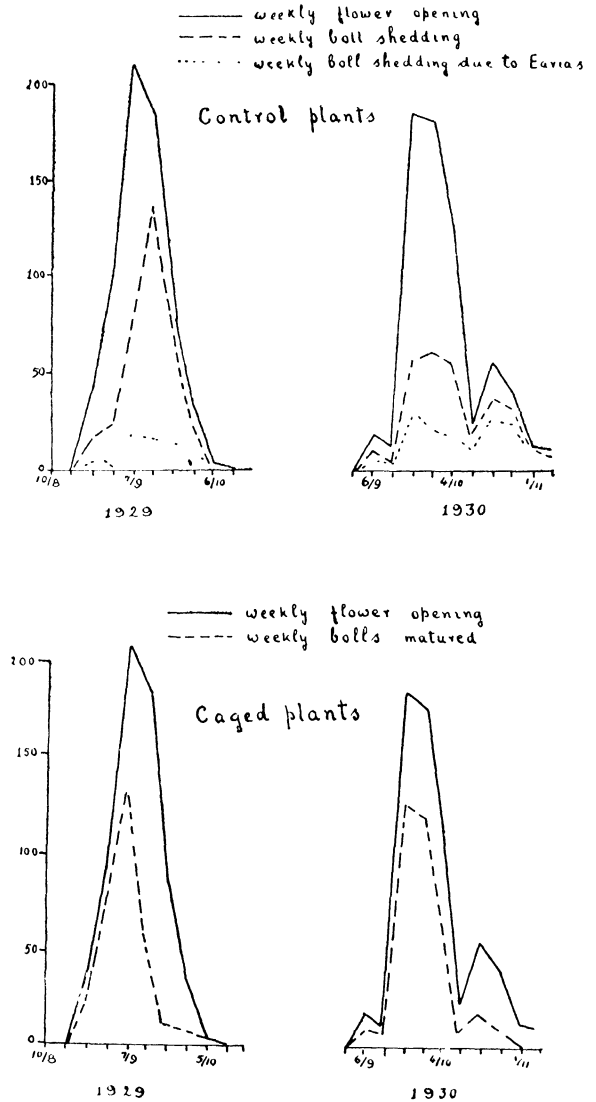
(In each case total figures from 100 plants are given)

—	Good *kapas* in tolas	Damaged *kapas* in tolas		Total *kapas* in tolas
		Due to boll-worms	Due to other causes	
Caged plants	84·7	10·5	1·4	96·7
Control plants (group No. 1) . . .	62·5	11·5	2·0	76·0
Control plants (group No. 2) . . .	63·7	10·7	1·0	75·5

The caged plants yielded about 26 per cent more *kapas* than the control plants, and probably this difference would have been greater if the developed bolls could have been effectively saved from damage by Pink Boll-worms.

SPOTTED BOLL-WORMS DURING THE OFF-SEASON

The cotton crop during 1929 was over at Jalgaon by the middle of November. After this the cotton plants began to put up fresh flower-buds and bolls, and therefore a plot of about ten *gunthas* was reserved on the Jalgaon Farm for noting the *Earias* population. One hundred fresh shoots were collected every week for examination.



Showing the weekly flower-opening, shedding of bolls and relative success of bolls from weekly flowers on cotton plants at Jalgaon.

TABLE VIII

Population of Earias *larvae from 100 shoots of cotton collected from the Jalgaon farm after the pickings were over*

1929-30

Weeks	Flower-buds	Bolls	Total *Earias* larvae
23rd November 1929.	239	54	22
30th November 1929	329	62	56
7th December 1929	359	97	77
14th December 1929	497	101	83
21st December 1929	576	92	72
28th December 1929	385	49	34
4th January 1930	260	38	22
11th January 1930	260	66	20
18th January 1930	283	52	21
25th January 1930	198	60	12
1st February 1930	211	66	20
8th February 1930	252	67	35
15th February 1930	220	57	16
22nd February 1930	159	61	9
1st March 1930	174	100	6
8th March 1930	123	96	10
15th March 1930	197	116	14
22nd March 1930	151	111	10
29th March 1930	170	85	10

Spotted Boll-worms continued to breed in this plot till the end of March; but the general cotton area in the District was almost completely cleared up by the end of January, as can be seen from the information collected regarding the standing cotton plots from two villages near Jalgaon. The total area under osbervation was 150 acres at Mamrabad and 130 acres at Asoda.

TABLE IX

Approximate estimate of the area of the standing cotton plots at Mamrabad and Asoda after the harvest of cotton crop of 1929

Dates of observation	Area with standing cotton stalks at Mamrabad	Area with standing cotton stalks at Asoda
8th December 1929	110	75
4th January 1930	40	40
11th January 1930	2	1
24th January 1930	0·5	*Nil*
1st February 1930	0·25	*Nil*

This must be considered to be a very early cleaning of the cotton fields, because in certain seasons the pickings of *kapas* continue till the end of January and consequently the removal of the cotton stalks continues for a couple of months more. It is unlikely, however, to find standing cotton fields in Khandesh after the month of March even if the season is late.

The cotton plants in Khandesh are removed by repeatedly working the blade harrow across the fields Most of the plants come out with the roots and a few stumps that remain in the soil do not sprout up. The fresh growth from stumps which is so common in Gujarat is practically absent in Khandesh.

Hibiscus rugosus, *Hibiscus ficulneous*, *Hibiscus manihot* and plants of *Abutilon* sp. are chiefly the wild food plants of *Earias* in Khandesh ; but none of them can be seen in green condition in the general cotton areas after the month of December. It was only at Kusumba in West Khandesh that a large number of plants of *Abutilon* sp. were found growing during summer in the irrigated plots.

Earias larvae, therefore cannot get any food in the general cotton fields in Khandesh after the month of March. There is, however, a large number of wells in several villages and there are small irrigated plots round many of these wells, which can supply water during the summer. It is in these plots that some of the food plants of *Earias* can thrive during summer.

There are about 12,165 acres in West Khandesh and 18,973 acres in East Khandesh which are irrigated by water from wells. As an instance we might state that 33 out of 111 villages of Jalgaon Taluka have more than 10 wells each, which supply water for irrigation, and of these there are 4 villages which have each more than 100 such wells.

It was decided to keep some of these plots under observation for recording the presence of the food plants of the Spotted Boll-worms in these plots. Three representative villages, *viz.* Nagardevala, Kusumba and Nimbhora, were, therefore, selected in addition to Jalgaon, for this purpose.

Some of the food plants, which were found in these plots and which could supply food to the *Earias* larvae during the period between the two cotton-growing seasons, were the following :—

(1) *Abutilon* sp. (2) Standing cotton plants of the previous season. (3) *Bhendi* (*Hibiscus esculentus*) plants.

Abutilon sp.

This is the only weed, which sometimes continues to thrive during the summer months, in the irrigated plots in Khandesh. It is not, however, very common and it was seen in large numbers in the gardens at Kusumba only.

TABLE X

Pods from plants of Abutilon *sp. from Kusumba*

Month of examination	No. of green capsules	No. of *Earias* larvae	REMARKS
January	200	44	Most of the larvae from these capsules belonged to the species, *Earias insulana*.
February	150	33	
March	90	14	
April	30	13	
May	..	1 (in flower-bud).	
June	15	1	
July	12	..	
August	100	2	

(2) STANDING COTTON PLANTS

The general cotton area is completely free from living cotton plants within a couple of months after the harvest of *kapas*. A few of these plants, however, could be found

growing along the borders and hedges of the irrigated plots in several places, and *Earias* larvae could be traced in flower-buds and bolls collected from these plants.

TABLE XI

Earias *larvae on flower-buds and bolls collected from cotton plants growing in irrigated plots*

Month of examination	Nagardevala		Kusumba		Nimbhora	
	Total flower-buds and bolls	*Earias* larvae	Total flower-buds and bolls	*Earias* larvae	Total flower-buds and bolls	*Earias* larvae
January	414	83	200	27	211	36
February	85	5	153	17	314	22
March	196	27	134	6	258	16
April	115	26	..	..	30	..
May	45	*Nil*	Forms not available hereafter.			
June	39	4	..	..	..	..
July	41	..	..	..	..	..
August	2,000	1	..	..	..	..

These forms were available at all the places till the end of March but it was only at Nagardevala that they could be collected till the commencement of the next crop.

Bhendi (*Hibiscus esculentus*)

The monsoon crop of *bhendi* is over by the month of October or November. A few stray plants of this crop, however, continue to grow in the irrigated plots. *Earias* larvae can be collected from them till February.

TABLE XII

Earias *larvae in* bhendi *pods from the remnant of the monsoon crop of* bhendi

Month	JALGAON		NAGARDEVALA	
	Pods examined	*Earias* larvae	Pods examined	*Earias* larvae
January 1930	10	9	20	20
February 1930	44	14	4	4

A second crop of *bhendi* is generally sown in March or April in the irrigated plots in several villages, and these plants are helpful for supplying food to the Spotted Boll-worms after March till the monsoon.

TABLE XIII

Earias *larvae in* bhendi *pods from the summer crop 1930*

Month of examination	JALGAON		NAGARDEVALA		KUSUMBA		NIMBHORA	
	Pods	larvae	Pods	Larvae	Pods	Larvae	Pods	Larvae
March . . .	88	15	..	..	..	..	..	..
April . . .	83	68	38	21	25	28	..	..
May	73	56	26	15	..	2*	..	..
June	22	14	25	15	..	3*	10	2
July	..	..	25	22	15	1	30	2

* In shoots.

The pods from the plots mentioned above are available in the local market after the middle of May and *Earias* larvae can often be collected from them,

TABLE XIV

Earias *larvae in* bhendi *pods, secured from the Jalgaon market from the local crop of* bhendi, *1930*

Weeks	No. of pods	*Earias* larvae
22nd May 1930	65	5
30th May 1930	82	6
7th June 1930	56	2
15th June 1930	65	5
21st June 1930	53	3
30th June 1930	45	13
7th July 1930	37	5
14th July 1930	59	2
21st July 1930	42	..
28th July 1930	46	3
2nd August 1930	71	2

Before this local supply of pods is available they are imported in Jalgaon market from Nasik district, during the months of April and May.

TABLE XV

Earias *larvae from market pods of* bhendi *from Nasik district*

Dates	No. of pods	No. of *Earias* larvae
14th April 1930	41	27
16th April 1930	52	33
26th April 1930	24	12
11th May 1930	32	10
17th May 1930	65	22

Possibilities of aestivation of the spotted boll-worms in Khandesh

There has been already enough evidence to show that in Khandesh also the Spotted Boll-worms are active throughout the year and their larvae can be collected from the irrigated plots even during the summer months. We wanted, however, to clear up the question about the likelihood of their aestivating in the cotton areas of Khandesh, as pupae in the soil or resting as moths. Small blocks of cotton area were, therefore, selected, when the cotton plants were removed after the harvest of *kapas*, and the soil from them was thoroughly examined to a depth of three to five feet (according to the depth of the cracks) in order to locate the pupae in the soil.

Table XVI

Results of soil examination for searching out Earias *pupae*

Time of soil examination	Area examined in square feet	Cocoons found	Live pupae
Two days after the plants were removed .	15×10	32	*nil*
22 days after the plants were removed .	15×5	66	*nil*
30 days after the plants were removed .	15×10	23	*nil*
45 days after the plants were removed .	10×10	11	*nil*

Bait pans with cotton and sesamum cakes, which usually attracted a large number of *Earias* moths (Appendix I, Tables X, XI, XXI and XXII) were continuously exposed in the cotton areas at Jalgaon, during summer after the cotton plants were removed. Not a single moth, however, could be collected from these pans during the period mentioned above.

In Khandesh also, therefore, we could not get any indications about the possibility of aestivation of the Spotted Boll-worms, during the period between two cotton-growing seasons.

Summary

The cotton crop in Khandesh escapes serious damage from the Spotted Boll-worms if it matures very early, before this pest gets an opportunity to increase in numbers. However, it cannot be considered to be a minor pest in years when the crop is delayed. In such seasons an increase of about 25 per cent in the yield of *kapas* might be expected if this pest can be controlled.

No indications were obtained of the possibilities of aestivation of this pest in Khandesh; and it was found to be active throughout the year.

The cotton areas are cleared up before the end of March and the stumps of cotton do not sprout, as they do in Gujarat; there is, therefore, no food available for these larvae in the general cotton areas.

Irrigated plots around the wells are found to be chiefly responsible for helping the carry-over of these insects from season to season, and the presence of *bhendi* plants in

these plots during the months of April, May and June appear to be most harmful, though stray plants of cotton and *Abutilon* weeds are also found to harbour *Earias* larvae in these plots to a certain extent. (Plate XXIV).

It appears that Spotted Boll-worms will no longer be a troublesome pest in Khandesh if the irrigated plots are kept free from plants, which afford food to these insects during the interval between two cotton-growing seasons.

It would be rather difficult to dissuade the cultivators from growing *bhendi* in these plots in summer, because it is considered to be a profitable crop.

Measures will also be necessary to prevent the importation of *bhendi* pods from other Districts to avoid fresh infection.

A few trials were made at Jalgaon, during 1930, of using *bhendi* as a trap crop The results have been discussed in pages 45-48.

TABLE XVII

Weekly rainfall at Jalgaon. (*Records from Government Farm*)

Months	Weeks	Rainfall in inches 1929	1930
June	first	0·90	..
	second	..	0·45
	third	6·23	4·22
	fourth	2·54	1·62
July	first	2·59	4·50
	second	2·03	..
	third	0·58	1·68
	fourth	0·16	0·53
August	first	0·60	3·62
	second	0·13	0·34
	third	..	..
	fourth	0·55	0·35
September	first	0·36	2·79
	second	..	15·92
	third	0·90	0·11
	fourth	0·31	..
October	first	0·86	..
	second	..	..
	third	..	..
	fourth	..	0·18
TOTAL	..	18·74	36·31

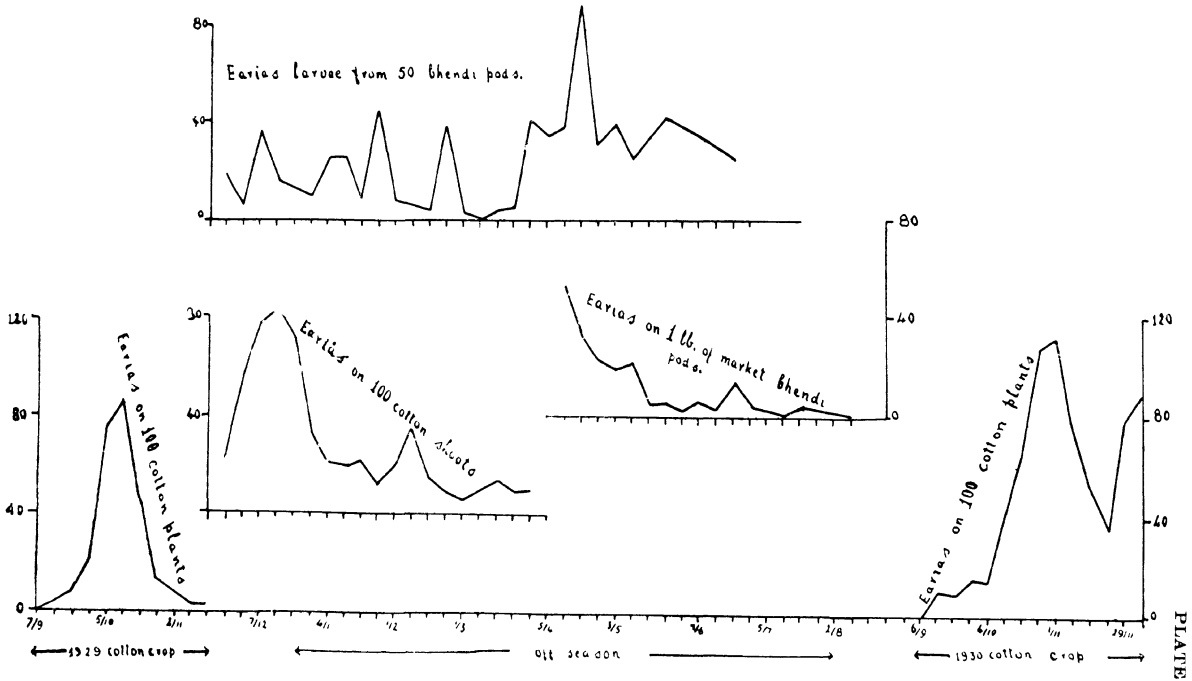


PLATE XXIV.

Showing sources of food for the Spotted Boll-worms during the period between two cotton-growing seasons in Khandesh

APPENDIX V

PHYCITA INFUSELLA MYER. (COTTON SHOOT-ROLLER) AT SURAT

This is another pest which is well established on cotton in South Gujarat. It appeared at Surat every year during the course of about eight years of the investigations on Spotted Boll-worms. A certain amount of information was incidentally collected about this pest.

The caterpillars of the cotton shoot-roller bind together the tender leaves of the cotton shoots and destroy the tiny growing buds. A part of one of the leaves is rolled up and the larva hides itself inside that. As a result of the damage of this pest, the further growth of the shoots is arrested. Periodical observations during 1925-26 showed that 62 per cent of the shoots of the main stems were damaged by these larvae.

Population of *Phycita* larvae on cotton crop

The incidence of this pest at Surat during four years commencing from 1927-28 can be seen from tables II to V of this Appendix. The attack of these larvae on the cotton plants begins when the seedlings are from 4 to 6 inches in height. Their population generally increases till the end of October or the beginning of November, when it begins to decline until it completely disappears from the cotton plants, or becomes almost insignificant, in March.

Hibernation

Of the four tables mentioned above, tables II and III show the classification of the larvae into three arbitrary classes, *viz.*, small, medium and big. This classification will show that during 1928, after the end of December, small-sized larvae could not be found, and again during 1929, the population of the small-sized larvae declined appreciably from the middle of November; so that after the middle of December, most of the larvae collected were of the big size. This indicated that these larvae hibernate either in November or December, and thereafter fresh oviposition practically ceases. These caterpillars roll up one or two leaves, which dry up, and the resting stage is passed in these leaves. As the season advances, these dry leaves drop away from the plants, along with the resting larvae, and therefore their number on the plants declines until they can no longer be found on the cotton plants during February and March. From the beginning of April fresh small-sized larvae begin to appear again on the cotton plants, and this, therefore, seems to be their time for coming out from hibernation.

Phycita larvae on standing cotton plants after harvest

By the time the pickings of *kapas* are over, the plants begin to put up fresh growth. It is, therefore, these new shoots, which are attacked by these larvae when they reappear

in the cotton fields. Table I will show that the population of these larvae on the standing cotton sticks increases very rapidly during April, May and June.

Phycita LARVAE ON SPROUTS FROM STUMPS

Periodical examination of the fresh shoots growing from the stumps of the cotton plants, which are usually removed by hacking with a light pick-axe, showed that *Phycita* larvae could easily be collected from these sprouts during May, June, July and August in 1928 and 1929. (Table I at the end of this appendix.)

It is thus seen that the caterpillars of *Phycita infusella* Meyr. feed on the shoots of the cotton plants from August till November or December, when they enter into a resting stage. They emerge from this stage at the commencement of April and sprouts from standing cotton plants and stumps constitute their source of food from April till the seedlings of the next crop are ready for their attack.

It appears that the large carry-over of this pest to the next crop can effectively be stopped if the cotton plants are uprooted immediately after the pickings are over, so that there are no standing cotton plants or their stumps to provide food for these worms. The clean-up measures against the Spotted Boll-worms (discussed on pages 91 and 92) are, therefore, very likely to be beneficial from the point of view of controlling this pest also.

TABLE I

Cotton shoot-rollers (Phycita infusella *Meyr.*) *on sprouts from stumps of cotton, Surat, 1928-29*

Date of examination	Sprouts from No. of stumps	No of larvae
10th May 1928	75	8
19th May 1928	75	19
25th May 1928	75	75
1st June 1928	100	5
7th June 1928	200	57
15th June 1928	200	22
22nd June 1928	200	33
30th June 1928	200	49

TABLE I—*contd.*

Cotton shoot-rollers (Phycita infusella *Meyr.*) *on sprouts from stumps of cotton, Surat, 1928-29*—contd.

Date of examination	Sprouts from No. of stumps	No. of larvae
9th July 1928	200	17
20th July 1928	200	8
31st July 1928	200	5
11th August 1928	200	10
15th August 1928	200	23
23rd August 1928	200	69
31st August 1928	200	53
4th May 1929	100	6
11th May 1929	100	10
18th May 1929	100	15
25th May 1929	200	17
1st June 1929	200	32
12th June 1929	200	26
22nd June 1929	200	4
27th June 1929	200	8
6th July 1929	200	5
18th July 1929	200	7
25th July 1929	200	7
3rd August 1929	200	19
10th August 1929	200	24
17th August 1929	150	16
25th August 1929	100	12

TABLE II

Larval population of Phycita infusella *Meyr. on cotton plants at Surat in 1927-28*

Week ending dates	No. of plants	No. of larvae	Week ending dates	No. of plants	No. of larvae
1	2	3	1	2	3
17th September 1927 .	25	9	3rd March 1928 . .	25	*nil*
24th September 1927 .	25	15	10th March 1928 . .	25	1
1st October 1927 .	25	41	17th March 1928 . .	25	1
8th October 1927 .	25	26	24th March 1928 . .	25	*nil*
15th October 1927 .	25	53	31st March 1928 . .	50	10
22nd October 1927 .	25	62	7th April 1928 . .	50	17
29th October 1927 . .	25	65	14th April 1928 . .	50	18
5th November 1927 .	25	56	21st April 1928 . .	50	31
12th November 1927 .	25	57	28th April 1928 . .	50	16
19th November 1927 .	25	64	5th May 1928 . .	50	27
26th November 1927 .	25	58	12th May 1928 . .	50	33
3rd December 1927 .	25	28	19th May 1928 . .	50	82
10th December 1927 .	25	27	26th May 1928 . .	50	44
17th December 1927 .	25	28	2nd June 1928 . .	50	54
24th December 1927 .	25	25	9th June 1928 . .	50	102
31st December 1927 .	25	25	16th June 1928 . .	50	142
7th January 1928 . .	25	20	23rd June 1928 . .	50	127
14th January 1928 . .	25	14	30th June 1928 . .	50	99
21st January 1928 . .	25	9	7th July 1928 . .	50	129
28th January 1928 . .	25	10	14th July 1928 . .	50	78
4th February 1928 .	25	12	21st July 1928 . .	50	70
11th February 1928 .	25	6	28th July 1928 . .	50	68
18th February 1928 .	25	3	4th August 1928 . .	50	66
25th February 1928 .	25	1	11th August 1928 . .	50	26

TABLE III

Larval population of Phycita infusella *Meyr. on cotton plants, with classification of the sizes of larvae, at Surat, 1928-29*

Week ending dates	No. of plants	Sizes of larvae			Total larvae
		Small	Medium	Big	
1	2	3	4	5	6
28th July 1928	1,350	0	1	0	1
4th August 1928	1,000	..	..	..	..
11th August 1928	1,000	3	6	1	10
16th August 1928	1,000	6	16	4	26
25th August 1928	750	7	10	13	30
1st September 1928	750	11	23	29	63
8th September 1928	250	2	8	4	14
15th September 1928	125	1	4	5	10
22nd September 1928		Plants not examined.			
29th September 1928	100	7	12	3	22
6th October 1928	50	5	8	3	16
13th October 1928	25	5	7	2	14
20th October 1928	25	5	3	2	10
27th October 1928	25	6	5	1	12
3rd November 1928	25	7	11	1	19
10th November 1928	25	3	10	1	14
17th November 1928	25	4	7	2	13
24th November 1928	25	3	6	4	13
1st December 1928	25	Sizes not noted			3
8th December 1928	25	Sizes not noted			4
15th December 1928	25	1	1	6	8
22nd December 1928	25	1	1	3	5
29th December 1928	25	1	3	1	5

TABLE III—*contd*

Larval population of Phycita infusella *Meyr. on cotton plants with classification of the sizes of larvae, at Surat, 1928-29*—contd

Week ending dates	No. of plants	Sizes of larvae			Total larvae
		Small	Medium	Big	
1	2	3	4	5	6
5th January 1929	25	..	1	4	5
12th January 1929	25	..	1	1	2
19th January 1929	25	..	1	2	3
26th January 1929	25	..	1	..	1
2nd February 1929	25	..	..	2	2
9th February 1929	25	..	..	1	1
16th February 1929	25	..	..	1	1
23rd February 1929	25	..	..	..	..
2nd March 1929	25	..	..	..	..
9th March 1929	25	..	..	..	..
16th March 1929	25	..	..	..	..
23rd March 1929	25	..	..	..	..
30th March 1929	50	..	..	..	..
Cotton pickings were over.					
6th April 1929	50	5	1	..	6
13th April 1929	50	4	4	1	9
20th April 1929	50	4	1	1	6
27th April 1929	50	10	5	1	16
2nd May 1929	50	27	11	..	38
9th May 1929	50	25	17	10	52
16th May 1929	50	18	21	14	53
23rd May 1929	50	13	11	18	42
30th May 1929	50	28	13	19	60

TABLE IV

Larval population of Phycita infusella *Meyr. on cotton plants at Surat*

1929-30

Week ending dates	No. of plants examined	Sizes of larvae			Total larvae
		Small	Medium	Big	
1	2	3	4	5	6
3rd August 1929	1,300	..	..	..	.
10th August 1929	887	14	4	..	18
17th August 1929	1,162	7	9	7	23
24th August 1929	396	4	4	7	15
31st August 1929	860	9	7	8	24
7th September 1929	750	2	2	4	8
14th September 1929	500	14	4	7	25
21st September 1929	250	8	6	4	18
28th September 1929	125	19	10	17	46
2nd October 1929	50	9	12	8	29
11th October 1929	25	22	9	6	37
16th October 1929	25	38	26	12	76
23rd October 1929	25	50	35	10	95
30th October 1929	25	54	38	19	111
8th November 1929	25	52	49	37	138
14th November 1929	25	24	48	60	136
21st November 1929	25	6	36	67	109
28th November 1929	25	3	25	75	103
5th December 1929	25	1	15	52	68
12th December 1929	25	..	5	57	62

TABLE IV—*contd*

Larval population of Phycita infusella *Meyr. on cotton plants at Surat*—contd

1929-30—*contd*

Week ending dates	No. of plants examined	Sizes of larvae.			Total larvae
		Small	Medium	Big	
1	2	3	4	5	6
19th December 1929	25	1	..	42	43
26th December 1929	25	..	..	32	32
2nd January 1930	25	..	..	39	39
9th January 1930	25	1	..	14	15
16th January 1930	25	..	..	7	7
23rd January 1930	25	..	..	4	4
30th January 1930	25	..	..	3	3
6th February 1930	25	..	..	2	2
13th February 1930	25	..	..	..	..
20th February 1930	25	..	..	..	..
27th February 1930	25	..	..	..	..
6th March 1930	25	..	..	..	..
13th March 1930	25	..	..	..	..
20th March 1930	25	..	..	..	..
27th March 1930	25	..	..	..	..
Cotton pickings were over.					
5th April 1930	50	1	..	..	1
11th April 1930	50	2	..	..	2
16th April 1930	50	2	1	1	4

TABLE V

Larval population of Phycita infusella *on cotton plants at Surat*

1930-31

Weeks of examination	No. of plants examined	Total larvae
13th August 1930	1,000	..
21st August 1930	1,000	10
26th August 1930	1,000	21
3rd September 1930	500	12
11th September 1930	200	9
18th September 1930	100	3
25th September 1930	50	11
3rd October 1930	25	10
10th October 1930	25	11
17th October 1930	25	28
24th October 1930	25	10
31st October 1930	25	14
7th November 1930	25	9
14th November 1930	25	6
21st November 1930	25	8
28th November 1930	25	4
5th December 1930	25	2
12th December 1930	25	5
19th December 1930	25	5
26th December 1930	25	3
2nd January 1931	25	5
9th January 1931	25	3
16th January 1931	25	1
23rd January 1931	25	..
30th January 1931	25	..

APPENDIX VI.

PINK BOLL-WORM (*PLATYEDRA GOSSYPIELLA* SAUND.) IN SOUTH GUJARAT

During the period of investigation on the Spotted Boll-worms at Surat, it was possible to make a few observations about the Pink Boll-worm also.

Twenty-five cotton plants were examined every week during the cotton-growing season, for recording the population of the Spotted Boll-worms (page No. 26). When these plants were examined, records of the Pink Boll-worm larvae were maintained. The results of these observations, made at Surat for seven years from 1924 to 1931, are included in Tables VII to XIII of this appendix. Table XIV shows the population of the Pink Boll-worm larvae during 1927-28 on the cotton crop on the Government Farm at Broach.

It will be seen from these tables that Pink Boll-worm is a well established pest in South Gujarat and that its earliest presence in the cotton fields can be noticed during October. There are no bolls on the cotton plants at that time, and hence their earliest appearance happens to be in flower-buds. In one case, a Pink Boll-worm larva was found in the vegetative shoot of the cotton plant. This was, however, an exceptional case. Though there are some instances of the presence of these larvae on the cotton plants during October, their number does not increase rapidly until well developed bolls are available on the cotton plants during December or January.

The figures further indicate that Pink Boll-worm cannot be normally considered to be a very serious pest in South Gujarat. This will probably be more clearly seen from statement No. XV of this appendix, which gives the number of green bolls examined every week from 25 cotton plants, and the number of Pink Boll-worm larvae calculated for 100 green bolls.

In four out of seven years, the population practically never increased to a level of even 10 larvae for every 100 green bolls. It was only during 1927-28 and 1928-29 it rose to about 25 larvae per 100 bolls, and the damage due to this pest to the cotton crop at Surat in 1928-29 might be considered to be the highest during all these years.

The population of the Spotted Boll-worms declines to a very low level by the end of December or the beginning of January, and it is about this time that the Pink Boll-worm larvae increase in numbers. This happens to be the period of the development of bolls, and hence the boll-worm damage which can be seen in the open bolls at Surat can almost completely be attributed to the Pink Boll-worms. In order to estimate this damage to the grown-up bolls more than 100 plants were kept under observation during 1928-29, 1929-30 and 1930-31.

At the time of collecting the *kapas*, all the bolls were carefully examined, and the *kapas* from sound and damaged locks was collected separately. The number of damaged and useless locks was also recorded.

TABLE I

Proportion of locks damaged by boll-worms, out of the total locks collected per plant during the above three years at Surat

Year	No. of plants observed	Total No. of locks picked	No. of sound locks	Damaged locks showing boll-worm injury	Useless locks showing boll-worm injury	Total locks with boll-worm injury	Percentage of locks with boll-worm injury
1928-29 . .	104	202	144	38	7	45	22
1929-30 . .	112	171	156	9	3	12	7
1930-31 . .	116	212	191	18	2	20	9

TABLE II

Proportion of kapas *from damaged locks out of the total saleable* kapas, *per plant, during the above three years at Surat*

Year	No. of plants observed	Total saleable *kapas* in grms.	*Kapas* from sound locks in grms.	*Kapas* from locks damaged by boll-worm in grms.	Percentage of damaged *kapas*
1928-29	104	130·6	105 5	25 1	19
1929-30	112	113 2	107 9	5 3	5
1930-31	116	150·1	140·7	9·4	6

From these statements it can be seen that during 1928-29, which appeared to be the worst Pink Boll-worm season at Surat, a fifth of the *kapas* came from the damaged locks. During the other two years the proportion of damaged *kapas* was only 5 and 6 per cent respectively.

RESTING STAGE OF PINK BOLL-WORM LARVAE

In the Punjab as well as in Egypt, the caterpillars of Pink Boll-worm pass the winter in hibernation [Bindra 1928 and Gough 1919]. In the Punjab the larvae enter into the resting stage during the months of October, November and December These larvae are known as the long-cycle larvae, to differentiate them from the short-cycle larvae which pupate as soon as they are fully fed, and emerge as moths after a normal period

of pupation. The emergence from the long-cycle larvae commences by the beginning of April. In South Gujarat, however, the period of boll development generally falls in the months of December and January, which are the coldest months ; and it is during these months that the population of the caterpillars of Pink Boll-worm increases rapidly. In order, therefore, to ascertain the presence or absence of the long-cycle larvae in South Gujarat, observations were undertaken on (1) green bolls, (2) the bolls rejected on the cotton sticks after harvest and (3) the *kapas* and seed.

Observations on green bolls

In the first week of January 1926 (about 4 weeks before the 1st picking of *kapas*), 800 fully developed green bolls were collected at random, and were allowed to dry in open cages ; because, if kept in closed jars, they began to rot within a short time. They were afterwards kept in 3 receptacles for noting the emergence of moths. Before the middle of March, 30 Pink Boll-worm moths emerged from these bolls, and then there was no emergence till the middle of April.

During the last fortnight of April, all these bolls were carefully examined and 63 caterpillars of Pink Boll-worm were found in them as mentioned below :—

30 larvae were found in flimsy lint cocoons.
25 larvae were found in single seeds.
7 larvae were found in double seeds.
1 larva was found free in the cage.

—

63 Total.

Another lot of 600 grown-up green bolls was collected on the 4th January 1926 and these bolls, after drying, were kept in earthen pots, which were covered with thin muslin cloth on the 4th February 1926. Emergence of moths from these bolls was recorded.

Table III

Time of emergence	No. of Pink Boll-worm moths
Before the 15th of March 1926	29
In July 1926	27
In August 1926	9
In September 1926	3
In October 1926	1
In November 1926	..
In December 1926	..
In January 1927	1

These observations in 1926 showed that long-cycle larvae did exist in South Gujarat also.

During the next season, 1,300 fully developed green bolls were collected when the second picking was in progress. They were kept in four cages, after drying, on the 29th of April 1927 for noting the emergence of the Pink Boll-worm moths from them.

TABLE IV

Month of emergence	No. of Pink Boll-worm moths
May 1927	29
June 1927	43
July 1927	259
August 1927	84
September 1927	3
October 1927	1

Another lot of 300 fully grown green bolls was collected on 8th April 1927, and was kept under observation as in the above case till the 21st July 1927, when all the bolls were removed for examination. Before this date, 49 Pink Boll-worm moths had emerged from these bolls : 11 in May, 6 in June, and 32 in July. Examination of these bolls disclosed 16 Pink Boll-worm larvae and 7 pupae as stated below :—

5 larvae in lint cocoons.
3 larvae in single seeds.
4 larvae in double seeds.
3 larvae in treble seeds.
1 larva in group of seeds.

16 Total larvae.

2 pupae in lint cocoons.
1 pupa in single seed.
1 pupa in double seed.
3 pupae free in the lint.

7 Total pupae.

These observations in 1927 show that it was not the cold which stimulated the larvae to display the long-cycle response because a large number of the long-cycle larvae were obtainable from the green bolls collected during April.

During 1927-28, samples of full grown bolls (green) each consisting of 250 bolls, were collected both at Surat and at Broach during the boll-development period. Four samples were collected at Broach and two at Surat. The dates of collecting these samples and the emergence of Pink Boll-worm moths from these bolls are shown in the table below.

TABLE V

Emergence of Pink Boll-worm moths from green bolls collected at intervals at Broach and Surat

Time of emergence	Broach sample No. I collected on 27th December 1927	Broach sample No. II collected on 14th January 1928	Broach sample No. III collected on 30th January 1928	Broach sample No IV collected on 28th February 1928	Surat sample No. I collected on 16th January 1928	Surat sample No. II collected on 23rd February 1928
Before 30th April 1928 .	85	20	..	5	11	..
In June 1928 . . .	..	..	1	2	1	1
In July 1928 . . .	8	1	7	24	..	17
In August 1928 . . .	3	3	..	9	..	6
In September 1928 . .	..	..	..	2	..	1

The bolls collected during February both at Surat and Broach have given the largest number of long-cycle larvae. Probably the number of the resting caterpillars would have been still greater if the samples had been collected even later, *i.e.*, in March or April.

OBSERVATIONS ON DRY BOLLS REJECTED ON THE PLANTS

There are always some damaged bolls which are left on the plants after the pickings are over. A few of these drop down to the soil, and the rest are carried along with the cotton sticks, which are stored in heaps. On the 27th of May 1926, 501 such dry bolls

were collected from 194 cotton plants from a stack. Examination of these bolls showed the presence of 44 Pink Boll-worm larvae in them. Fifteen of these larvae were found in single seeds, 27 were found between the compact locks of lint and the carpels and two were found parasitised.

In the next season, two lots of similar dry bolls were collected on the 27th of May 1927. The first lot consisting of 247 bolls was collected from 105 plants, and the second lot of 302 bolls was collected from 109 plants.

The first lot was examined after the 15th of July 1927, and one pupa of Pink Boll-worm and five full grown Pink Boll-worm caterpillars were obtained from these 247 bolls. The bolls from the second lot were kept under observation for noting the emergence of Pink Boll-worm moths. Only one moth emerged from these bolls on the 16th of August 1927.

There is thus a possibility of a small number of the long-cycle larvae resting in the dry bolls left out on the cotton plants after the harvest of *kapas*.

Observations on *kapas* and seed

Examination of kapas. Two pounds of *kapas* collected from the general lot at Surat was examined from 8th to 23rd June and 12 Pink Boll-worm caterpillars were found in it.

7 larvae in single seeds.
3 larvae in lint cocoons.
2 larvae free in the lint.

—

12 Total.

Another sample of two lbs. of *kapas* from the second picking was examined from 26th June to 5th July and only one Pink Boll-worm larva was found in a single seed.

Besides this, two samples of *kapas*, of one pound each from the first and the second pickings respectively, were kept in jars for noting the emergence of Pink Boll-worm moths. From one pound of *kapas* of the first picking, only one Pink Boll-worm moth emerged on the 11th of August 1928; and from the sample from the second, one moth emerged in the 3rd week of July and another in the last week of July.

Examination of seed. Small quantities of cotton seed from the *kapas* of the first and second pickings were examined by splitting open every seed during July and August 1928. The cotton seed was obtained by ginning the *kapas* with hand gins. All the seeds which showed damage caused by the boll-worms, were kept separate and the total quantity was weighed at the end of each examination. The number of Pink Boll-worm larvae found in the seeds can be seen from the next table. All the caterpillars were found in single seeds.

TABLE VI

Examination of cotton seed

1928

Quantity of seed examined	No. of Pink boll-worm larvae found	Quantity of damaged seed	Time of examination
		Tolas	
2 lbs. from 1st Picking	5	7	July.
2 lbs. from 1st Picking	1	7·75	August.
1 lb. from 2nd picking	..	2·5	July end.
1½ lb. from 2nd picking	3	5·25	August.

It is thus seen that the *kapas* as well as the cotton seed both have a small number of resting Pink Boll-worm caterpillars in them.

Some of the baits which were tried for collecting the moths of Spotted Boll-worms attracted the moths of Pink Boll-worm also as can be seen from tables VIII to XI of appendix No II.

CONCLUSIONS

Pink boll-worm appears every year in the cotton fields in South Gujarat. It increases in number during December and January, but normally it does not cause a very serious damage to the cotton crop. About twenty-five larvae for every 100 bolls were recorded only in two out of the seven seasons during the worst period of the attack.

During 1928-29, which was the worst Pink Boll-worm year, 19 per cent of the *kapas* was picked from damaged locks, whereas during the next two seasons the proportion of the damaged *kapas* was 6 and 5 per cent respectively.

The long-cycle larvae are found in this tract, and this pest is carried over from one season to another by these larvae resting in *kapas*, in cotton seed and in the dry bolls rejected in the cotton fields. The exact responsibility of each of these in the carry-over of the pest could not, however, be worked out.

It was further seen that the maximum emergence of the Pink Boll-worm moths from the resting larvae takes place in July. The emergence declines in August, and after

the end of August, there is only a very occasional emergence in September and October. During July and August there is practically no food available for these worms on the cotton crop, as it is sown at the end of June or at the beginning of July. The plants are consequently very small, and even flower-buds are generally absent. Probably from the stray emergence of moths during September and October, a small infestation continues on the flower-buds and young bolls until developed bolls are available. These developed bolls are usually available in December and the pest has, therefore, to carry on its mere existence till that time. From December onwards, the population begins to rise rapidly.

The long interval between the period of the emergence of the moths from the resting stage and the period of the availability of the developed bolls (which is the principal food of these larvae) seems to be the chief factor, which prevents this pest from assuming alarming proportions in this important tract of cotton.

TABLE VII

Weekly population of Pink Boll-worm larvae on 25 cotton plants at Surat (1924-25)

Week ending	No. of flower-buds	Larvae in flower-buds	No. of bolls	Larvae in bolls	Total Pink Boll-worm larvae
12th December 1924 . .	2,260	7	367	7	14
19th December 1924 . .	2,095	3	644	11	14
26th December 1924 . .	1,652	8	876	8	16
2nd January 1925 . .	971	*nil.*	1,005	59	59
9th January 1925 . . .	461	1	1,000	29	30
16th January 1925 . .	205	*nil.*	1,110	46	46
23rd January 1925 . .	172	*nil.*	865	14	14
30th January 1925 . .	102	*nil.*	979	16	16
6th February 1925 . .	14	*nil.*	962	28	28
13th February 1925 .	..	..	583	14	14
20th February 1925 . .	..	..	625	39	39
27th February 1925 . .	..	..	357	27	27
6th March 1925 . . .	..	..	116	5	5

TABLE VIII

Weekly population of Pink Boll-worm larvae on 25 cotton plants at Surat (1925-26)

Week ending	No. of flower-buds	Larvae in flower-buds	No. of bolls	Larvae in bolls	Total Pink Boll-worm larvae
18th December 1925 . .	323	..	151	1	1
25th December 1925 . .	927	..	1,186	29	29
1st January 1926 . . .	401	1	1,127	61	62
8th January 1926 . . .	97	..	966	68	68
15th January 1926 . .	49	..	821	85	85
22nd January 1926 . .	24	..	838	99	99
29th January 1926 . .	..	..	795	131	131

TABLE IX

Weekly population of Pink Boll-worm larvae on 25 cotton plants at Surat (1926-27)

Week ending	No. of flower-buds	Larvae in flower-buds	No. of bolls	Larvae in bolls	Total Pink Boll-worm larvae
28th January 1927 . .	2,090	..	229	2	2
4th February 1927 . .	1,890	..	439	..	..
11th February 1927 . .	1,991	..	794	12	12
18th February 1927 . .	1,271	..	1,081	12	12
25th February 1927 . .	682	..	1,071	14	14
4th March 1927 . . .	195	..	888	46	46
11th March 1927 . . .	9	..	801	69	69
18th March 1927 . . .	..	..	731	51	51
25th March 1927 . .	..	..	690	32	32
1st April 1927 . . .	..	..	286	11	11
8th April 1927 . . .	..	..	116	3	3

TABLE X

Weekly population of Pink Boll-worm larvae on cotton plants at Surat (1927-28)

No. of plants	Dates	Flower-buds	Larvae in flower-buds	Bolls	Larvae in bolls	Total Pink Boll-worm larvae
25	16th September 1927	..	..	..	..	1 in shoot.
25	28th October 1927	1,158	2	..	..	2
25	4th November 1927	1,263	2	..	..	2
25	11th November 1927	1,976	..	..	..	..
25	18th November 1927	2,392	4	2	..	4
25	25th November 1927	2,421	..	13	2	2
25	2nd December 1927	2,302	5	2	2	7
25	9th December 1927	2,496	6	107	9	15
25	16th December 1927	3,501	3	170	6	9
25	23rd December 1927	3,541	6	189	7	13
25	30th December 1927	3,530	4	406	28	32
25	7th January 1928	3,204	..	487	17	17
25	14th January 1928	2,763	3	1,156	60	63
25	21st January 1928	1,849	..	1,164	18	18
25	28th January 1928	968	..	1,357	33	33
25	4th February 1928	607	..	1,629	35	35
25	11th February 1928	105	..	1,270	63	63
25	18th February 1928	56	..	1,001	87	87
25	25th February 1928	14	..	857	123	123
25	3rd March 1928	4	..	527	67	67
25	10th March 1928	..	..	300	18	18

TABLE X—*contd*

Weekly population of Pink Boll-worm larvae on cotton plants at Surat (1927-28)—contd

No. of plants	Dates	Flower-buds	Larvae in flower-buds	Bolls	Larvae in bolls	Total Pink Boll-worm larvae
25	17th March 1928 . .	..	..	183	19	19
25	24th March 1928 . .	..	..	72	8	8
50	31st March 1928 . . .	58	..	51	11	11
50	5th April 1928 . . .	107	..	16	4	4
50	13th April 1928 . . .	346	..	1	..	..
50	20th April 1928 . . .	350	..	2	..	..
50	27th April 1928 . . .	386	..	1	..	..
50	4th May 1928 . . .	471	..	21	..	..
50	9th May 1928 . . .	665	..	30	..	..
50	18th May 1928 . . .	488	..	43	..	..
50	23rd May 1928 . . .	362	..	58	..	..
50	31st May 1928 . . .	346	..	74	3	3
50	8th June 1928 . . .	278	..	48	1	1
50	13th June 1928 . . .	132	..	18	5	5
50	20th June 1928 . . .	69	.	8	1	1
50	27th June 1928 . . .	83	..	4	..	..
50	4th July 1928 . . .	280	..	6	..	..
50	11th July 1928 . . .	136	.	8	1	1
50	17th July 1928 . . .	130	..	8	5	5
50	24th July 1928 . . .	54	..	11	7	7
50	3rd August 1928 . . .	93	1	4	1	4 2 in shoot.
50	8th August 1928 . . .	37	..	7	2	2

TABLE XI

Weekly population of Pink Boll-worm larvae on cotton plants at Surat (1928-29)

No. of plants	Dates	No. of flower-buds	Larvae in flower-buds	No. of green bolls	Larvae in bolls	Total Pink Boll-worm larvae
25	9th November 1928 . .	2,758	1	4	..	1
25	16th November 1928 . .	2,767	4	50	..	4
25	23rd November 1928 . .	3,096	4	119	4	8
25	30th November 1928 . .	3,235	..	210	2	2
25	8th December 1928 . .	3,201	3	314	1	4
25	14th December 1928 . .	2,797	2	338	13	15
25	21st December 1928 . .	2,915	1	610	7	8
25	29th December 1928 . .	3,162	..	863	28	28
25	4th January 1929 . .	1,744	..	863	22	22
25	11th January 1929 . .	1,025	..	851	6	6
25	18th January 1929 . .	804	..	1,062	12	12
25	25th January 1929 . .	681	..	1,005	32	32
25	1st February 1929 .	188	..	1,027	71	71
25	8th February 1929 . .	30	..	794	107	107
25	15th February 1929 . .	3	..	761	200	200
25	22nd February 1929 . .	1	..	586	143	143
25	29th February 1929 . .	..	..	416	100	100
25	8th March 1929 . . .	..	..	175	21	21
25	15th March 1929 . .	5	..	35	4	4
25	22nd March 1929. . .	17	..	10	..	..
50	28th March 1929 . .	75	..	2	..	..
50	6th April 1929 . . .	293	..	4	..	..
50	12th April 1929 . . .	319	..	16	..	..
50	19th April 1929 . . .	554	..	26	..	..
50	25th April 1929 . . .	469	..	39	1	1
50	2nd May 1929 . . .	310	..	44	..	..
50	10th May 1929 . . .	337	..	26	..	..
50	16th May 1929 . . .	354	..	21	..	..
50	24th May 1929 . . .	231	..	17	1	1
50	29th May 1929 . . .	467	..	54	6	6

TABLE XII

Weekly population of Pink Boll-worm larvae on cotton plants at Surat (1929-30)

No. of plants	Dates	No. of flower-buds	Larvae in flower-buds	No. of green bolls	Larvae in bolls	Total Pink Boll-worm larvae
25	30th October 1929	1,667	1	8	..	1
25	8th November 1929	1,993	..	5	..	..
25	14th November 1929	2,627	..	17	..	..
25	21st November 1929	2,529	..	20	..	..
25	28th November 1929	3,381	..	32	..	..
25	5th December 1929	3,637	..	72	2	2
25	12th December 1929	3,829	..	149	2	2
25	19th December 1929	2,673	..	338	1	1
25	26th December 1929	2,831	..	493	..	..
25	2nd January 1930	2,537	..	866	3	3
25	9th January 1930	1,721	..	1,350	..	..
25	16th January 1930	940	..	1,814	6	6
25	23rd January 1930	288	..	1,468	19	19
25	30th January 1930	67	..	1,102	18	18
25	6th February 1930	20	..	1,170	31	31
25	13th February 1930	5	..	947	22	22
25	20th February 1930	..	..	882	14	14
25	27th February 1930	..	..	693	10	10
25	6th March 1930	..	..	334	2	2
25	13th March 1930	..	..	67	2	2
25	20th March 1930	..	..	13	1	1
25	27th March 1930	..	..	3	..	..
50	5th April 1930	16	..	..	..	..
50	11th April 1930	43	..	1	..	..
50	16th April 1930	198	..	3	..	..
50	23rd April 1930	263	..	6	..	..
50	29th April 1930	323	..	10	..	..
50	6th May 1930	395	..	19	1	1
50	14th May 1930	591	..	49	1	1
50	22nd May 1930	628	..	86	1	1
50	27th May 1930	620	..	243	2	2

TABLE XIII

Weekly population of Pink Boll-worm larvae on 25 plants at Surat (1930-31)

Dates	Buds	Larvae in buds	Bolls	Larvae in bolls	Total Pink Boll-worm larvae
21st November 1930 . .	2,688	1	32	1	2
28th November 1930 . .	3,998	2	75	11	13
5th December 1930 . .	5,192	5	208	8	13
12th December 1930 . .	4,224	15	288	17	32
19th December 1930 . .	4,207	21	868	28	49
26th December 1930 . .	3,919	25	1,707	87	112
2nd January 1931 . .	2,198	4	1,895	65	69
9th January 1931 . . .	927	2	2,167	57	59
16th January 1931 . .	225	3	1,692	48	51
23rd January 1931 . .	18	..	1,248	51	51
30th January 1931 . .	1	..	1,165	81	81
6th February 1931 . .	..	..	1,287	84	84
13th February 1931 . .	..	..	894	56	56
20th February 1931 . .	..	..	470	27	27
27th February 1931 . .	..	..	102	9	9

TABLE XIV

Weekly population of Pink Boll-worm larvae on 25 plants each week

1927-28 (Broach)

Dates	Buds	Larvae in buds	Bolls	Larvae in bolls	Total Pink Boll-worm larvae
10th December 1927 . .	2,520	..	379 .	2	2
17th December 1927 . .	2,449	1	836	19	20
24th December 1927 . .	1,081	..	676	19	19
31st December 1927 . .	632	..	939	17	17
7th January 1928 . . .	429	..	755	56	56
14th January 1928 . .	366	..	592	36	36
21st January 1928 . .	95	..	642	45	45
28th January 1928 . .	38	..	671	38	38
4th February 1928 . .	8	..	609	38	38
11th February 1928 . .	..	..	580	42	42
18th February 1928 . .	..	..	457	40	40
25th February 1928 . .	..	..	349	15	15
3rd March 1928 . . .	..	..	464	7	7

TABLE XV

Pink Boll-worm larvae for every 100 bolls examined

Weeks.		Surat Farm														Broach	
		1924-25		1925-26		1926-27		1927-28		1928-29		1929-30		1930-31		1927-28	
		Bolls	Larvae per 100 green bolls	Bolls	Larvae per 100 green bolls	Bolls	Larvae per 100 green bolls	Bolls	Larvae per 100 green bolls	Bolls	Larvae per 100 green bolls	Bolls	Larvae per 100 green bolls	Bolls	Larvae per 100 green bolls	Bolls	Larvae per 100 green bolls
1	November	..	..	..	.	..	..	..	.	4	.	..	..	..	..	..	..
2		..	.	.	.	..	..	..	..	50	.	..	..	..	..	..	..
3		..	..	.	..	..	..	2	..	119	3	..	..	32	3	..	..
4		.	..	..	.	..	..	13	15	210	1	32	..	75	15	..	..
1	December	..	.	..	..	..	..	107	9	314	.	72	3	208	4	379	1
2		220	2	151	1	..	.	170	4	338	4	149	1	288	6	836	2
3		644	2	1,186	3	..	..	189	4	610	1	338	..	868	3	676	3
4		1,881	4	1,127	5	..	..	406	7	863	3	1,359	..	3,602	4	939	2
1	January	1,000	3	966	7	..	.	487	3	863	3	1,350	..	2,167	3	755	7
2		1,110	4	821	10	..	.	1,156	5	851	1	1,814	..	1,692	3	592	6
3		865	2	838	12	..	.	1,164	2	1,062	1	1,468	1	1,248	4	642	7
4		979	2	795	16	229	1	1,357	2	2,032	5	1,102	2	1,165	7	671	6
1	February	962	3	..	..	439	..	1,629	2	794	13	1,170	3	1,287	7	609	6
2		583	2	..	..	704	2	1,270	5	761	26	947	2	894	6	580	7
3		630	6	..	.	1,081	1	1,001	9	586	24	882	2	470	6	457	9
4		359	8	..	..	1,071	1	857	14	416	24	693	1	102	9	349	4
1	March	116	4	..	..	888	5	827	10	175	12	334	1	.	..	464	2
2		..	..	..	..	801	9	183	10	35	11	67	3	..	..	..	..
3		..	..	..	..	731	7	72	11	10	..	13	7	..	..	..	..
4		..	..	..	..	976	4	51	22	2	..	3	..	..	..	..	..
1	April	..	..	..	..	116	3	16	25	4	..	..	..	..	..	..	..
2		..	.	..	..	..	..	1	..	16	..	..	..	..	..	..	..
3		..	..	..	..	..	..	2	..	26	..	..	.	.	..	..	..
4		..	..	..	..	..	..	1	..	39	3	..	..	..	..	..	..
1	May	..	..	.	..	..	..	..	..	..	..	..	..	..	..	..	..
2		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
3		..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
4		..	..	..	..	..	..	.	..	.	..	..	..	..	..	..	..

APPENDIX VII

PINK BOLL-WORM (*PLATYEDRA GOSSYPIELLA* SAUND.) IN KHANDESH

A few observations about the Pink Boll-worm were maintained during the period of work upon Spotted Boll-worms of nearly 18 months in Khandesh. The incidence of the larval population of this pest in the cotton fields during 1929 and 1930 can be seen from the following tables :—

TABLE I

Larval population of Pink Boll-worm on 100 cotton plants from Government Farm, Jalgaon

1929

Weeks	No. of green bolls	No. of Pink Boll-worm larvae	REMARKS
24th August 1929	49	1	
31st August 1929	148	..	
7th September 1929	270	3	
14th September 1929	305	..	Bolls began to open.
21st September 1929	622	3	
28th September 1929	774	5	
5th October 1929	734	12	
12th October 1929	488	14	1st picking.
19th October 1929	210	38	
26th October 1929	100	47	2nd picking.
2nd November 1929	55	36	
9th November 1929	23	6	
16th November 1929	6	..	Last picking.

TABLE II

Pink Boll-worm larvae from 50 full-grown green bolls collected from the standing cotton stalks on Jalgaon Farm

1929-30

Weeks	No. of Pink Boll-worm larvae
23rd November 1929	28
30th November 1929	90
7th December 1929	69
14th December 1929	59
21st December 1929	4
28th December 1929	47
4th January 1930	71
11th January 1930	38
18th January 1930	44
25th January 1930	44
1st February 1930	9
8th February 1930	15
15th February 1930	18
22nd February 1930	13
1st March 1930	9
8th March 1930	20
15th March 1930	13
22nd March 1930	5
29th March 1930	4

TABLE III

Pink Boll-worm larvae on 100 cotton plants from Jalgaon Farm

1930

Weeks	No. of green bolls	No. of larvae	REMARKS
4th October 1930	499	...	
11th October 1930	585	2	
18th October 1930	458	19	
25th October 1930	576	73	1st picking.
1st November 1930	458	75	
8th November 1930	315	48	
15th November 1930	154	18	
22nd November 1930	170	147	2nd picking.
29th November 1930	154	169	
6th December 1930	145	156	
13th December 1930	181	294	Last picking.
20th December 1930	103	156	
27th December 1930	141	138	
3rd January 1931	80	25	
10th January 1931	140	109	
17th January 1931	344	228	
24th January 1931	338	209	
31st January 1931	496	237	

TABLE IV

Larval population of Pink Boll-worm on 50 cotton plants from villages near Jalgaon during 1930-31

Fortnights of examination		Mamurabad		Pimrala		Nagardevala	
		Green bolls	Larvae	Green bolls	Larvae	Green bolls	Larvae
September	1st Fortnight .	79	..	155	..	626	18
	2nd Fortnight .	241	5	147	..	..	..
October	1st Fortnight .	291	34	152	43	318	105
	2nd Fortnight .	446	166	169	34	..	..
November	1st Fortnight .	338	75	103	55	155	157
	2nd Fortnight .	75	52	78	110	..	..
December	1st Fortnight .	203	335	57	42	150	149
	2nd Fortnight .	65	55	58	54	..	..
January	1st Fortnight .	99	85	86	68	..	..
	2nd Fortnight .	100	72	73	17	..	..

The cotton season of 1929 was very early and practically all the crop was over before the population of Pink Boll-worm could rise. During 1930, however, the rapid multiplication of these insects had begun at about the time when the first picking of cotton was in progress. From the last week of November till the last week of December there was found a larger number of these larvae than the total number of bolls which were examined. Even after the last picking was over a large number of green bolls could be collected from the cotton fields but no *kapas* was available from them because most of them were destroyed by this pest.

In order to determine the period when the caterpillars hibernated in Khandesh, 200 full grown green bolls were collected, three times during the season of 1929 when the first, second and the third pickings respectively were in progress. The emergence from these bolls is given in the next table.

TABLE V

Emergence of Pink Boll-worm moths from developed green bolls collected on different dates

Month of emergence	Number of Pink Boll-worm moths which emerged		
	200 bolls collected on 4th October 1929	200 bolls collected on 15th November 1929	200 bolls collected on 18th November 1929
October 1929	2	7	..
November 1929	1	15	..
December 1929	..	1	78
January 1930	..	1	8
February 1930	..	1	5
March 1930	..	..	5
April 1930	..	..	2
May 1930	..	..	..
June 1930	..	..	4
July 1930	1	6	28
August 1930	..	..	2

After the pickings are over there are always some dry bolls, which remain on the plants, being rejected as useless bolls at the time of collecting *kapas*. There is a possibility of the long-cycle larvae resting in these bolls. These bolls either drop away in the fields or are carried along with the cotton sticks, which are generally heaped up for fuel purposes. Two hundred such bolls were collected on 17th January 1930 from one of the heaps and were kept under observation.

From these bolls, two Pink Boll-worm moths emerged in July 1930 and three more moths came out in August 1930.

From the information upon the emergence of these moths from green bolls collected at different times of the season, it appears that the largest number of larvae hibernate when the crop is about to be over Some of these long-cycle larvae can also be found in the dry bolls which are rejected on the cotton plants.

A few moths emerged practically every month till August 1930, from the bolls which were collected in November 1929 ; but the largest number of moths emerged during July 1930. There was no emergence after August.

Some of the moths which emerged from the resting stage were kept under observation to note their longevity. Seventeen of them were kept without any food, nine of them were given only water, and the remaining two were offered diluted molasses. (Table VI App. VII.)

The average life of the moths which were kept without any food was 8 days although one of them lived for 24 days. The moths which were supplied with water only, lived for 11 days on an average, and the maximum period of life was 19 days. The moths which were given diluted molasses lived for 25 and 30 days respectively.

It will be seen from Table II (App. VII) that the short-cycle larvae continued to breed in the cotton fields on the fresh growth from the standing plants till the end of March 1930.

The information collected about this pest in Khandesh is scanty and refers practically to only one complete season. However, it appears that Pink Boll-worm is a more serious pest in Khandesh than the Spotted Boll-worms, and that the damage due to this pest is greater in years when the crop is delayed due to heavy rains during September, October or November. The damage is not restricted to the dirty *kapas* which finds its way to the market, but there is, in addition, a large number of bolls which are entirely valueless and have to be rejected at the time of collecting the *kapas*

TABLE VI

Longevity of life of the Pink Boll-worm moths emerging from resting stage at Jalgaon

1930

Serial No. of moths	Date of emergence	Date on which the moth was dead	Total life in days
	Moths kept unfed.		
1	30th June 1930	7th July 1930	7
2	11th July 1930	20th July 1930	9
3	19th July 1930	23rd July 1930	4
4	19th July 1930	28th July 1930	9
5	21st July 1930	28th July 1930	7
6	22nd July 1930	23rd July 1930	1
7	22nd July 1930	23rd July 1930	1
8	22nd July 1930	26th July 1930	4
9	22nd July 1930	27th July 1930	5
10	22nd July 1930	1st August 1930	10
11	22nd July 1930	15th August 1930	24
12	25th July 1930	5th August 1930	12
13	26th July 1930	4th August 1930	9
14	26th July 1930	5th August 1930	8
15	28th July 1930	31st July 1930	3
16	4th August 1930	16th August 1930	12
17	8th August 1930	27th August 1930	19
		Average life	8
	Moths which were given water only.		
1	4th July 1930	8th July 1930	4
2	14th July 1930	21st July 1930	7
3	19th July 1930	30th July 1930	11
4	19th July 1930	1st August 1930	13
5	19th July 1930	4th August 1930	16
6	19th July 1930	30th July 1930	11
7	23rd July 1930	26th July 1930	3
8	23rd July 1930	4th August 1930	12
9	23rd July 1930	11th August 1930	19
		Average life	11
	Moths which were given diluted molasses.		
1	28th July 1930	22nd August 1930	25
2	28th July 1930	27th August 1930	30

APPENDIX VIII

CAPACITY OF THE COTTON PLANT TO REPLACE ITS FORMS SHED DUE TO THE BOLL-WORM INJURY

It has been established that the Spotted Boll-worms appear in the cotton field as soon as vigorous growth of the cotton plant commences, and continue to feed on them throughout the season. The flower-buds and the young bolls which are attacked by the worms drop down from the plant, resulting in a continuous wastage of the reproductive organs of the cotton plant. It is, of course, inconceivable that the cotton plant should mature all its flower-buds and flowers into bolls, but it was not very clear if all the shedding due to the insects was a net loss, or if the plant possessed a capacity to recover any loss from such shedding by stronger development of the forms which would normally appear later, or by augmenting their number by additional bud formation.

A small beginning for ascertaining the possibilities was, therefore, made during 1925, when a group of only five plants was selected, and the flowers that appeared on them were pruned continuously up to a fixed date in the case of each plant. Thus the pruning of flowers from the first plant was stopped on the 30th of November; and that from the others on the 10th December, 20th December, 30th December, and 10th of January respectively. The flowers that appeared after these dates were not disturbed. Daily flowering was recorded from the commencement of the experiment and the shed bolls were collected to examine if they were attacked by the boll-worms. The results are tabulated below :—

TABLE I

Dates up to which the flowers were pruned	Plant numbers				
	1	2	3	4	5
	30th November	10th December	20th December	30th December	10th January
Number of flowers pruned .	6	49	236	75	118
Total number of flowers opened.	96	120	287	81	118
Number of flowers opened after pruning was stopped.	90	71	51	6	*Nil*
Number of mature bolls .	33	37	40	4	*Nil*
Number of bolls shed after pruning was stopped.	57	34	11	2	*Nil*
Bolls shed due to boll-worm	10	7	7	*Nil*	*Nil*
Bolls shed due to other causes	47	27	4	2	*Nil*

The results of these observations on single plants could not be taken as conclusive evidence, but indicated that the plants had responded, in their effort to make up the number of mature bolls, by developing a large proportion of flowers immediately after the removing of flowers was stopped. The performance of the plant No. 3 especially deserves admiration in as much as it yielded 40 mature bolls from 51 late flowers, after undergoing the pruning of 236 of its first flowers.

The continuation of the removal of flowers from plants Nos. 4 and 5 ultimately proved disastrous to the plants, as only six flowers could open on plant No. 4 after the pruning was stopped; and there was no more flowering on the 5th plant after the tenth of January. It was thus indicated that the plant cannot stand an indefinite destruction of its flowers, and that any unusual and continuous damage to the flowers would exhaust the capacity of the plant to replace the lost forms.

Experiments on a larger scale were undertaken in 1926. A total number of forty plants was grown free from boll-worms by "night caging", to avoid the disturbing factor of the shedding due to boll-worms in addition to the artificial removal of the forms. Out of these, 15 plants were used for the pruning of the flower-buds, and the remaining 25 for the trials of the flower pruning.

The first 15 plants were divided into 3 groups of 5 plants each. The first group was reserved as a control. From the second, all the flower-buds formed up to the 30th of October were pruned. From the third, the flower-buds were similarly pruned on the 13th of November. Care was taken to remove only such of the flower-buds as could be nipped off without injuring the growing points, and therefore the smallest flower-buds were left alone Thus 236 flower-buds were removed of the total of 358 existing on the plants of the 2nd set on the 30th of October; and 202 buds out of 336 present on the plants of the 3rd set on the 13th of November. Records of the weekly flower-bud formation, flower opening and the relative success of flowers to bolls were maintained. (Tables III and IV of this Appendix.)

The result of the flower-bud pruning (as can be seen from the tables) was that the flowering was delayed by four weeks in the second set, and by seven weeks in the third one. The flowering, however, when it appeared showed a much higher intensity and a larger proportion of the first flowers was retained than in the control plants. Attention is drawn to another important fact, that after the pruning of the flower-buds, the fresh flower-bud formation in both pruned sets, continued at a higher level for longer periods than that in the control set. This indicated that not only does the plant respond to the loss of its flower-buds by retaining its later forms, but that it also augments bud formation by new development.

Flower-pruning

The remaining 25 plants were divided into 5 sets of 5 plants each. Four sets were used for the removal of the flowers and the fifth was retained as a control. The flowers that appeared in all the sets (except the control) were removed daily up to the 13th November. 27th November, 11th December, and the 25th of December respectively.

Records of daily flower-opening, the number of flowers removed, number of flowers that opened after the removal of flowers was stopped and the relative percentage of flowers that developed into mature bolls were maintained. (Table V of this appendix.)

Examination of the curves of flower opening (Plate XXV) shows that the peak of flowering is reached in all the sets at about the same time but that, where the removal of flowers is prolonged, the intensity of flower opening continues to be higher, instead of declining as in the control plants. The prolongation of the high rate of flower opening, following continued flower-pruning, naturally increases the average number of flowers per plant, in proportion to the duration of the period of the removal. The average performance of the plants from the above five sets is shown in the following table.

TABLE II

Results of flower-pruning

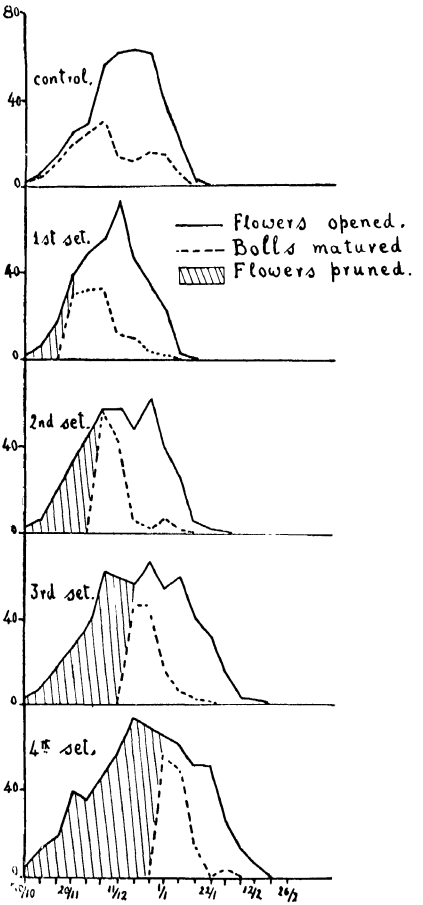
(Average per plant of 5 plants in each case)

Treatment	Flowers per plant	Flowers pruned	Flowers opened after pruning was stopped	Mature bolls per plant
Control	75	*Nil*	75	30
1st set (flowers pruned up to 13th November) . .	70	5	65	25
2nd set (flowers pruned up to 28th November) .	81	20	61	22·8
3rd set (flowers pruned up to 11th December) . .	107	42	65	23·6
4th set (flowers pruned up to 25th December) . .	126	71	55	24·2

It will further be seen that the number of mature bolls per plant is not substantially different, and curiously enough the number of bolls shed in every case is almost similar except in the last case; showing that the plants had an adequate supply of flowers to develop into bolls and even a few more to shed in the normal course, even after the pruning of the first flowers.

These experiments have, therefore, shown that the cotton plant under Surat conditions evinces a large capacity for replacing the lost flower-buds or flowers, by development of its later forms, which might otherwise have shed. It further indicates a certain degree of auto-regulation of the formation of flower-buds and flowers, thus assuring enough supply of these forms for the requirement of the plant.

It should, however, be remembered that the preliminary experiment indicated that this capacity for replacing forms is limited, and that the plant is unable to make good the destruction of its forms indefinitely.



Pruning of Flowers 1926-27.

Showing weekly flowering, proportion of flowers pruned and the number of successful bolls from weekly flowers in the flower-pruning experiments of 1926-27

TABLE III

Flower-bud formation, flower-opening and the success of flowers into mature bolls from five plants where 226 flower-buds were removed on the 30th of October, 1926

(5 plants in each case)

Weeks	Control plot			226 flower-buds removed		
	Flower-bud formation	Flower opening	Success of flowers to bolls	Flower-bud formation	Flower opening	Success of flowers to bolls
3rd October . . .	..	..	..	20	..	..
10th October . . .	40	..	..	31	..	..
17th October . . .	63	..	..	73	..	..
24th October . . .	85	..	..	97	..	..
30th October . . .	116	4	4	137*	..	..
6th November . . .	201	15	12	192	..	..
13th November . . .	147	26	19	194	..	..
20th November . . .	163	37	21	230	..	..
27th November . . .	132	48	38	217	13	12
4th December . . .	133	57	36	138	96	81
11th December . . .	100	60	9	118	107	47
18th December . . .	28	79	16	61	110	16
25th December . . .	19	69	10	23	112	20
1st January . . .	4	35	7	5	82	25
8th January . . .	2	17	4	4	39	8
15th January . . .	..	4	..	..	16	1
22nd January . . .	..	1	..	..	1	..

* 226 flower-buds removed on the 30th of October 1926.

TABLE IV

Flower-bud formation, flower-opening and the relative success of flowers into mature bolls from five plants where 202 flower-buds were removed on the 13th November 1926

(5 night-caged plants in each case)

Weeks	Control plants			Plants with 202 flower-buds removed		
	Flower-bud formation	Flower opening	Success of flower to bolls	Flower-bud formation	Flower opening	Success of flowers to bolls
10th October . . .	40	..	..	8	..	..
17th October . . .	63	..	..	27	..	..
24th October . . .	85	..	..	43	..	..
30th October . . .	116	4	4	64	..	..
6th November . . .	201	15	12	98	..	..
13th November . . .	147	26	19	96*	..	..
20th November . . .	163	37	21	140	..	..
27th November . . .	132	48	38	171	..	..
4th December . . .	133	57	36	132	..	..
11th December . . .	100	60	9	108	..	..
18th December . . .	28	79	16	100	47	46
25th December . . .	19	69	10	49	97	70
1st January . . .	4	35	7	44	82	12
8th January . . .	2	17	4	15	85	3
15th January .	..	4	..	5	69	4
22nd January . .	..	1	..	1	24	2
29th January . .	..	..	..	..	4	..

* 202 flower-buds removed on the 13th November 1926.

TABLE V

Statement showing daily flower opening, flower pruning, boll shedding and the percentage success of bolls from the different sets of the flower pruning experiment.

1926-27

Week ending	CHECK :—(10 PLANTS)			1ST SET :—(5 PLANTS)			2ND SET —(5 PLANTS)			3RD SET —(5 PLANTS).			4TH SET —(5 PLANTS).		
	Flowers	Bolls Shed	% success	Flowers	Bolls Shed	% success	Flowers	Bolls Shed	% success	Flowers	Bolls Shed	% success	Flowers	Bolls Shed	% success
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
30th October 1926 .	3	.	100	1	Pruned	..	1	Pruned		2	Pruned	..	2	Pruned	..
6th November 1926	11	1	90 9	6	,,		9	,,	..	7	,,	..	13	,,	..
13th November 1926	28	2	92 9	17	,,	.	19	,,	..	17	,,	..	18	,,	..
20th November 1926	49	9	81 6	37	7	81 1	33	,,	.	25	,,	..	38	,,	..
27th November 1926	57	8	86 0	48	16	66 6	43	,,	..	37	,,	..	36	,,	..
4th December 1926	111	50	55 0	56	23	58 9	58	2	96 7	63	,,	.	48	,,	..
11th December 1926	121	94	22 3	74	62	16 2	58	17	70 7	59	,,	.	58	,,	..
18th December 1926	125	101	19 2	46	37	19 6	49	44	10 2	55	9	83 6	74	,,	..
25th December 1926	122	93	23 8	35	31	11 4	62	60	3 2	66	20	69 7	71	,,	..
1st January 1927 .	79	51	35 4	24	22	8·3	41	34	17 1	54	36	33 3	65	7	89 2
8th January 1927 .	38	28	26 3	6	3	50 0	26	23	11 5	60	55	8 3	61	12	80·3
15th January 1927 .	6	6	.	.	..	.	5	5	.	41	39	4 9	51	38	25 5
22nd January 1927	..	..	..	.	.	..	1	1	..	31	30	3 2	51	51	..
29th January 1927 .	..	..	..	..	.	..	..	..	..	15	15	..	27	26	3·7
5th February 1927	..	..	..	..	..	.	..	..	..	4	4	..	14	14	..
12th February 1927	..	..	..	..	..	..	..	..	..	1	1	..	7	7	..

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