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NOTES ON COTTON

IN BEHAR IN 1904

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Agricultural Research Institute, Pusa, Bengal.

NOTES ON
COTTON IN BEHAR
IN 1904

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NOTES ON COTTON IN BEHAR.

THE following notes on cotton growing in Behar are published for the information of planters and others interested in cotton. The notes on the cultivation of cotton have been revised by F. G. Sly, Esq., Officiating Inspector General of Agriculture, and by F. Fletcher, Esq., Deputy Director of Agriculture, Bombay. These notes have been compiled from observations made at Pusa and during my tours in Behar, and I take this opportunity of expressing my indebtedness to planters who gave me opportunities of visiting their cotton cultivation.

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NOTES ON COTTON IN BEHAR IN 1904.

The experiments with cotton at Pusa have not yet given any definite results which will help cotton experiments elsewhere in Behar, and still more is it impossible to offer any recommendation in regard to general cotton cultivation in Behar. But as several planters are themselves making experiments, it is hoped that the following observations based upon my examination of cotton at Pusa and other parts of Behar may prove of some use to persons who still desire to experiment with cotton, particularly in regard to the important matter of cotton pests. A considerable area of cotton has been grown during the year 1904-1905 in Behar, with a small area left from 1903 sowings. At the present time the results are very indefinite. The matter will be clearer by next April and May when the growing crop has been harvested. The main points to be aimed at are :—(1) Vigorous cotton plants yielding freely either at regular intervals or in one crop after a short time ; (2) Good lint, fetching a high price ; (3) Cotton that does not yield in the rains ; (4) Plants free from disease.

(1) It is important that cotton should come in bearing all at once, giving few pickings ; one may aim at a short-lived plant yielding freely and then dying (as in India generally) or a more permanent plant which yields heavily at certain seasons and which is pruned or cut down every season (Perennial cottons such as Tree cottons, Sea Island, and others). The gross yield of cotton lint and seed must be high and the proportion of lint as large as possible.

(2) The question of good lint for the market is one that cannot be considered here. Samples of all cotton grown this season should be submitted to brokers or experts for valuation at once.

(3) Cotton should not bear in the rains; it will do so if allowed to grow for two seasons and not cut down before the second rains, but such cotton has little value.

(4) Plants free from disease are produced by good cultivation and treatment. No fungoid diseases are apparently to be found but insect pests are observed. It should be remembered that most of these can be checked, that they are worst from June to October, and practically do not harm cotton in the winter. It is therefore important to get cotton to yield during and after the winter, the latter being probably the best. There is some importance in choosing varieties not attacked by certain pests but this is a smaller matter than the above considerations. Cotton sown in early June and yielding in September is much more liable to insect pest than cotton sown in September and yielding in March.

Varieties.—Some hundreds of varieties may be seen at Pusa but agriculturally the cottons grown may be classed as :—

(1) Behār Dēshi, *i.e.*, Indigenous cotton.
(2) Other Dēshis.
(3) Acclimatised American Cotton.
(4) American Cotton.
(5) Tree Cottons.
(6) Egyptian Cotton.

We may consider them in order, in the light of the above points.

(1) Behār Dēshi is the ordinary cotton grown by cultivators with Arhar or other crops. It is a vigorous growing plant, healthy and fairly free from diseases. The yield is uncertain as yet. It thrives with other crops that draw much of the moisture from the soil, making its chief growth after they are removed. It may be accepted that something better than this cotton is to be aimed at.

(2) *Dēshi* Cottons, *e.g.*, Broach, Navasāri, Goghāri. As grown by planters, they form vigorous bushy plants, with great vegetative vigour and little fruiting vigour. Some fifteen months old cotton has never yielded. It withstands the rainy season better than other cottons and grows freely. It is liable to three pests, Stem Weevil, Bud Moth and Mealy bug, which do not attack some other cottons. On the whole, whilst these cottons may be an improvement on the Behār Dēshi, there is no reason to believe they are worth growing by planters. The yield must first be determined.

(3) Acclimatised American Cotton (Dharwar and Cawnpore cotton). These have stood the climate better than any except Dêshi kinds. Acclimatisation produces a healthy plant but also deterioration in lint (J. Mollison). Seed of American varieties acclimatised in other parts of India does better than newly imported seed, it grows best, is free from most pests, yields before the cold weather (and probably after), and in some cases seems to do well in the second year. These acclimatised Americans give some promise of ultimate success. It would be worth experimentally growing the best seed under the conditions discussed below.

They suffer from leaf caterpillar, and Green Leaf Hopper, which are far less serious than other pests and easily checked.

(4) American Cotton (Allen's Hybrid, Texas Big Boll, King's Improved, Boyd's Prolific, Russell Long Staple, Truitts Big Boll, etc.). These have almost universally done badly or died out. This is due, not to disease, but to adverse conditions. Allen's Hybrid, King's Improved and Boyd's Prolific show some promise. The important point with them is to preserve the seed for next year from the best plants of the present year, remembering that acclimatisation improves the plants, that nearly all unacclimatised seed failed this year, that for every estate the conditions are different. The seed of the best plants, which is now one year's acclimatised, should do better next year. If American cotton is to do well, it will be this seed that is acclimatised here. Further, under favourable conditions, American cotton has been grown and has yielded this season; the question is one of favourable conditions and cultivation not fully understood as yet but which may be so in a short time. Then the acclimatised seed will be worth growing. The seed of only the best plants that yielded this year should be kept and sown experimentally next year. It would be unwise to plant large areas.

(5) Perennial Cottons, such as Tree Cottons, Caravonica, Sea Island, and the like.—This class includes a great variety of cottons of which little is yet known. It is probable some may do well, yield freely and prove remunerative: at present no variety can be recommended, and only experiment will show what can be grown on any estate. It is uncertain when or how these cottons will yield, whether they will stand the winter, what pests they get. Plants that are not vigorous are attacked by pests. The indigenous tree cottons of Behar are extraordinarily vigorous and healthy, apparently yielding largely; but they are grown under peculiar conditions and may not grow so well in the fields. They show promise, and every variety found in the District deserves a trial.

(6) *Egyptian.*—(Yennovitch, Metafifi, etc.).—Little has been grown and there is not enough to give any definite conclusions. Grown with irrigation in April, it has yielded a tall plant, suffering much from pests in the rains and not promising. No better results are gained by growing in June without irrigation. Egyptian cotton seems very unpromising.

Cultivation, etc.

Cotton in Behar failed largely as it could not stand the wet season. No other conclusion is possible. Insect pests generally had nothing to do with it, nor can other diseases be found. It was simply excessive moisture. On the whole, cotton in land under trees was far more healthy than cotton not near trees; cotton with Makai and Urid was better than cotton with Makai alone, and the latter was far better than cotton alone; cotton on higher land was better than on low lying land; the whole points at once to drainage. Cotton would have done much better with a small rainfall, or on better drained land. In some cases the Makai was sown much too thickly smothering the cotton. The problem is one of the drainage or of otherwise improving the conditions; that is paramount. This fully agrees with the conditions under which cotton is grown generally, as in United States of America, West Indies, the Deccan, Sind, and Egypt.

There seem to be three ways of improving methods of cotton cultivation :—

(1) Drainage. (2) Growing with other crops. (3) Sowing at another time of the year.

It is not possible to say what will be the effect of these, but they are the lines on which experiments should be tried. I would suggest (1) sow some on ridges, two feet or more apart, at least twelve inches high. This is done with Barbados Sea Island cotton (the best in the world) and with American cotton. At the same time, any possible drainage would be of advantage.

(2) Sow other crops with the cotton, *e.g.*, Makai or Urid, or any other crop that will grow and suck up the moisture; that is a matter that I am not competent to discuss but must be worked out by experiment.

(3) *Sow at another time, not in June.*—The cotton was sown in June, and in April with irrigation (Egyptian and American). Neither was a success. I would advise sowing some trial plots in August, September and October. If the cotton germinates then, it will not have to struggle through the long rainy season, it will be well established by the end of November and should come on well in the following hot weather. In

this way not only will the wet be avoided, but the insect pests which are worst in June, July and August will not affect it, and the cotton will be produced in the dry weather before the rains. If the plant of perennial variety is then cut down it may grow freely in the next rains and yield again in the second year. This would appear to best approximate to the conditions under which cotton is grown elsewhere, and to be the experiment best worth trying. At the same time it is not certain how the cotton will stand the winter, and this can only be regarded as an experiment to be tried on a small scale.

The conclusions arrived at now are generally :—

(1) That the seeds of the best plants of the American cotton grown this year should be kept for resowing on a small scale.

(2) That this resowing should be done :

(*a*) in June with other crops and on ridges, in the best lands with every possible drainage or help to water extraction,

(*b*) in August, September and October, both on the flat and on ridges.

(3) That acclimatised American seed may be worth another trial.

(4) That every tree cotton found on the estate deserves a trial, as well as other tree cottons of different types.

(5) That in no case should cotton be grown with a view to profit in the first year but only as an experiment.

There are other considerations, but I have discussed the main problems and indicated what I believe to be the rational course.

The question of manures cannot be gone into here ; some experiments can be seen at Pusa, and cases have been seen where the close proximity of saltpetre works improved the cotton. The pests are a minor feature of the problem and will be discussed later : one may say that Dëshi are liable to the worst that American suffers from preventable pests, and that there are some that attack all alike. There is nothing to show that there is any pest-proof variety, and for each variety of cotton certain pests can be expected and destroyed. There are some hundreds of varieties of cotton under trial at Pusa, but since on each estate the results are not the same, the experiments there should be checked by small experiments on each estate.

Insect Pests of Cotton in Behar.

A total of 14 pests of cotton are known in Behar, of which 3 are at present known in Behar only, and 11 are general to cotton in India.

Some of these have not been fully worked out, and it is only possible to indicate what should be done to check them. Full accounts of others will be published this year, with illustrations, and any planter growing cotton who desires to know more about these pests can obtain information from the Entomologist.

Shorter accounts of the commoner ones are being printed in leaflet form, and copies of these will be sent to any planter who finds the pest on his cotton.

At present a very short diagnosis of each pest is given, so that the pest may be recognised easily, and the method of treatment is indicated.

These pests do not attack all the cottons grown; I state here what varieties are attacked by each pest, classing the cottons as :—

(1) Bengal Dēshi, *i.e.*, the indigenous cotton grown in Behar by cultivators.
(2) Broach and other Dēshi kinds, mostly from Bombay.
(3) American including the new American kinds such as Allen's Hybrid, etc.
(4) Acclimatised American, being Dharwar American, Cawnpore American, Nagpur American, etc.
(5) Egyptian cotton.
(6) Tree Cottons.

A.—Insects attacking the Leaves, and seen chiefly up to September.

1. *Hairy Caterpillars (No. 136).*—The hairy caterpillars that come in numbers and devour the crops, are well known on indigo and cotton, etc. These are the caterpillars of moths and injure cotton by eating the leaves. They are liable to appear several times in a year, and probably must be destroyed if a good crop is to be got. I have had no opportunity of studying them; probably no other treatment is possible than to use Lead Arseniate, spraying or dusting it on the plants to poison them. This is effective against other caterpillars and will be used this season at Pusa, as it is elsewhere. I shall be glad to arrange to do this as an experiment on planters' crops when possible; it is probably the best treatment also for indigo caterpillars.

2. *Cotton Leaf Caterpillar (No. 37).*—A smooth shiny greenish caterpillar, with black head, of a length of one inch, which eats the leaves and folds them over. Especially attacks the American, American acclimatised and Egyptian cottons. It is active in the rains, developing quickly, one brood coming after another without cessation.

This insect feeds on the Lady finger (Bhinda, or Rumtiroes) and from that attacks cotton. It is important not to grow this plant at all on estates where the cotton is grown as it brings the pest. (This applies also to the bollworms, red bug and dusty bug.) Where the pest is found early in the season, it must be destroyed by hand picking, a gang of coolies picking off the caterpillars into tins, in which a little kerosine and water is placed. If this is not done when the caterpillar first comes, it will multiply so fast as to render this impossible; then there will be no remedy but to spray with Lead Arseniate or to dust this on. This pest is likely to be serious if not checked, but it can be checked if taken in time.

3. *The Cotton Budworm (No. 80).*—A small green caterpillar, not more than one-third of an inch long, which lives in the leaves at the end of the shoot and ties them together into a little knot. This knot withers, and that shoot cannot grow any further. The pest is chiefly found on Dēshi cottons and is not serious as a rule. If much is found it is easily picked off, the little withered mass at the end of the shoot being simply picked off and burnt.

4. *The Spotted Bollworms (No. 73.108).*—Dark coloured spotted caterpillars, short and fat, which destroy the top shoots by boring down from the tip; they are worst in Egyptian and American cottons. This damage is itself not important, but as these insects later attack the bolls, it is important to check them at this time. If these withered branches are cut off and burnt, the first brood will be destroyed; this must be done in August. If it is not done, the later broods attack the bolls and there will be much loss of cotton.

5. *The White Weevil (No. 6).*—A small whitish weevil, which is very common on cotton and indigo. It eats the leaves and except when very abundant does no harm.

6. *The Cotton Leaf Hopper (No. 82).*—A very tiny green fly, found in great numbers in American cottons especially, when these are weak. This pest may be neglected if the cotton is strong and healthy; if it is weak and stunted the insect will suck the leaves, cause them to wrinkle and turn red, and may finally kill them. It is not really a pest but an indication of an unhealthy plant. It can be checked on valuable plants by spraying with Crude Oil Emulsion, but this is not worth doing unless the plants are especially valuable.

B.—Insects in the Stem.

7. *The Stem Borer (No. 60).*—Sometimes a cotton plant dies suddenly withering in a few days; this is due to a long white grub, which has eaten

out the centre of the stem, just above the ground. It is found in Dēshi cottons, and is a common pest in Bombay. It has been found once in Behar. There is only one treatment, to pull out these withered plants and burn them, in order to check the second brood. It is mentioned here as it may increase in Behar, but it is not as yet a serious pest.

8. *The Stem Weevil (No. 140).*—It is found that the Egyptian, Dēshi and Tree cottons are attacked by a minute weevil, whose grub tunnels in the stem just above the ground. The grub is a very small white worm which eats the stem inside: the stem swells at that point, and when a high wind comes, the plant breaks off. Very many plants were lost from this cause in 1904. At present no remedy is known for it; it has not been studied in detail. It is probably advisable not to grow Egyptian cottons, or Broach Dēshi, or certain tree cottons, where this pest is found.

I can only advise a careful watch on the plants from the first, to see if any are swollen at the base and have the pest. It will be carefully studied this year at Pusa and if any planter finds it, he should communicate with the Entomologist at Pusa.

C.—Insects in the Boll.

4. } *The spotted bollworms (No. 73.108).*
9. }

The pink bollworm (No. 74).

These three caterpillars eat the growing bolls; they may be found in the bolls, the first two being dark, with white and yellow spots, the latter white with pink spots or quite pink.

They are very common and will be found whenever there are bolls.

No treatment is known which will save a boll once attacked; the remedy advised for the spotted bollworms above must be adopted in August, or before the bolls are formed, as the insects are then eating the stems, waiting till the bolls are formed. There is one further remedy: when the first crop of bolls form, they should be picked over, the wormy ones all removed and burnt. The wormy ones can be distinguished by the holes made by the worm in getting in. If this is done early in the season the first brood in the bolls is killed and there are few left to multiply.

10. *The Red Cotton Bug (No. 69).*—This is a conspicuous red insect, with a black diamond mark at the hind end of the back. It looks like a red beetle, but is a plant-bug. It sucks the juice of the developing bolls, pushing a long slender beak right into the boll, till it can reach and suck

the seeds. It was very abundant at Pusa in 1904 and was destroyed by coolies, who had each a paddy winnow and a kerosine tin with a little kerosine. He held the winnow under the plant, shook the bugs into it, and then shook them into the tins where the kerosine killed them. This is quite simple and very cheap. This insect must be checked or there will be great loss of lint and seed.

11. *The Dusky Cotton Bug* (*No. 5*).—A very small dark coloured bug which is found in open bolls. As a rule it attacks only bolls which have been eaten by the bollworms and open prematurely. It is a sound practice to pick off the bolls periodically and burn them. They are useless, do no good on the plant and only breed this pest.

D.—Miscellaneous.

The Mealy Bug (*Coc. 51*).—This is a small white bug that lives on the shoots of the Dēshi cotton; these swell and twist, forming a peculiar hard gall-like knot; Dēshi cotton suffers much from this pest. The simple treatment is to pull off all these shoots as soon as they are seen. When Broach and other Dēshis are grown the plants should be looked at when they are, say, a foot high, and when this bug is seen among the leaves, it must be pulled off, the shoot being removed and burnt.

13. *The large Blister Beetle* (*No. 50*).—A large black beetle with orange bands and spots, which is found feeding on the flowers of cotton. It is not a pest, unless present in very large numbers, and does not breed in cotton. If it comes in large numbers it must be collected by hand. From the above account, it would appear as if cotton could not possibly be grown with all these pests in it, but it may be remembered that they do not all attack one kind of cotton, and that many can be checked.

The important things to do are:—

(1) During the rains to watch for caterpillars and destroy them.
(2) In August or September, to look out for the bollworms killing the shoots and cut the shoots off.
(3) To pick off the first lot of bolls attacked by bollworms.
(4) To pick off all the unsound bolls and burn them, not leaving them on the plants.
(5) Not to grow lady's finger (Bhinda) within a mile of a cotton plant.
(6) To check the red cotton bug directly it appears.

The Bengal Dēshi. Suffers little from pests, as it is hidden among

other crops almost until the cold weather comes on. Bollworms, stem borers and mealy bug attack it.

Broach Dēshi.—Suffers from stem borers, from the mealy bug, from red bug, and from bollworms. Caterpillars also attack it but not so much as other cottons.

American.—Suffers from leaf caterpillars, from bollworms in the shoots and bolls, from red bug, and from Green leaf hopper.

Egyptian.—Suffers from leaf caterpillars, from stem weevil, from bollworms in the stem and boll, from red bug.

Tree Cottons.—Caravonica suffers from stem weevil, bollworms, and from a peculiar mealy bug (Coc. 20). The red bug attacks some kinds, but many are free from pests so far as observed.

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Agricultural Research Institute, Pusa

AN OUTBREAK OF COTTON PESTS IN THE PUNJAB, 1905

JANUARY 1906

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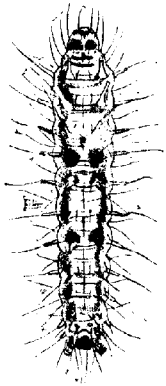
1909

BOLLWORMS.

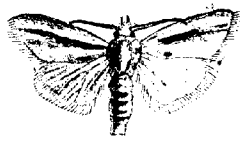


The spotted Bollworm.
Magnified four times.

The spotted Bollworm.
Magnified four times.

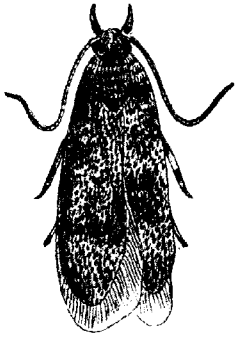
Moth of spotted Pollworm.
Magnified three times.

Cocoon of spotted Bollworm.
Magnified three times.



Moth of spotted Bollworm.
Twice Magnified.

BOLLWORMS.

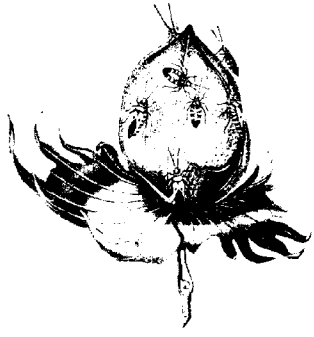


Pink Bollworm Moth.
Magnified five times.

Pink Bollworm.
Magnified four times.

Pink Bollworm. Magnified four times, and its chrysalis case (Natural size).

Cotton Boll attacked by Bollworm



Red Cotton Bugs on Cotton Boll.

S. H. Morgan, del.

Attacks of the Duki Fig-Tree Borer

AN OUTBREAK OF COTTON PESTS IN THE PUNJAB, 1905.

Report on Cotton Pests in the Punjab in 1905.

1. The failure of this season's cotton crop in the majority of the cotton-growing districts of the Punjab was due to the action of insect pests, assisted to some extent by climate and other conditions. In general the sequence of events has been somewhat as follows. The failure of rain from the middle of July to the middle of September gave the plants a set-back even on canal irrigated lands and caused a varying amount of loss on unirrigated lands. During this time, two pests were at work, the cotton semilooper in the Jhelum Colony, the cotton aphis (*tela*) throughout the Province. These pests further weakened the plants at a critical time, but had disappeared before the September rain fell. After the rain, the cotton grew luxuriantly with the promise of a large crop. This promise was not fulfilled, the flower buds and young bolls being destroyed as they formed by bollworms, which were now found in large numbers over the greater part of the Province. So great was this damage that plants actually vigorous and healthy produced little or no cotton, and the final loss of crop is due to this pest. The bollworm is the important pest, without which a full crop would probably have been obtained, and the following pages deal mainly with this insect.

The Cotton Semilooper Caterpillar (*Turache entella*, Sow.).

2. This insect was seen as a green caterpillar, about one inch long, which defoliated the cotton plants, leaving only the bare branches. The plants put out new leaves, but were weakened and thrown back by the attack. The caterpillars on completing their metamorphosis appeared as white moths with lead coloured markings, large numbers of which were destroyed by light traps. The caterpillars did not reappear; the outbreak is noticeable only as indicating the abnormal character of the season: this insect is

common in India generally as a harmless caterpillar feeding on cotton in small numbers only ; its increase in such large numbers was abnormal and is unlikely to occur in the next season.

3. Cotton aphis (*tela*) is a pest universal in India on cotton. It appears to have increased rapidly during August, seriously infesting the cotton plants. As the individuals are all females which produce living young at a rapid rate, the increase of this pest is very rapid if food is plentiful. The young themselves are capable of reproducing after a few days, so that a few aphides can, in a short time, give rise to a vast number. These spread over the field, constantly feeding and reproducing; they extract the sap from the leaves and young shoots, weakening the plant ; they also drop a sweet liquid on the leaves, which dries to a gummy covering in which a black mould lives ; this black mould gives the leaves a sooty appearance which is very striking and which is probably the first sign of aphis seen by the cultivators. Aphis is checked by enemies, which feed upon it, and which this season probably came in the normal manner. Aphis was probably destroyed before the rain fell in September, though the cultivators believe the rain washed it away ; the rain washed off the black on the leaves, the evident sign of aphis, which remained on after the insects themselves were destroyed by their enemies. In November only small quantities of aphis remained, and the ladybird beetles which feed on aphis were common in the fields.

4. Aphis is not an insect that can be readily checked when it has a good hold of a crop, except by its natural enemies; if aphis is to be checked artificially, prompt measures must be taken in good time. It may in time be possible to educate the ryot to the pitch of looking out for the first colonies of the aphis and destroying them (a very easy matter), but this cannot be expected at present. Nor can any practical method be devised of increasing the beneficial insects which destroy aphis or of bringing them upon the scene earlier. I believe this will be possible in the future when a sufficient staff is available in each province, but it cannot be attempted now. No remedy for aphis can be advised for general use, and progress can be made only by spreading information about the beneficial insects and by experimentally checking aphis on the Lyallpur Farm.

Cotton bollworm (*Earias insulana*, Boisd.).

5. The rain of September fell on cotton weakened by want of rain and by the ravages of aphis. The plants appear to have then grown vigorously and commenced to put out flower buds a little later in the season than usual. At this time, bollworm (*Sundi*) was first seen, this pest continuing in evidence until the cold stopped its work. The life history of bollworm is briefly as follows:—The moth lays eggs singly on the flowers, the buds, the bolls, the leaves or the bracts; from each egg comes a small caterpillar which feeds by preference first in the flower bud; each little bud is eaten out and the partially grown caterpillar then enters another bud or, if available, a green boll. When full grown, the caterpillar spins a silken cocoon in the boll, on the bract, on the leaf, or, in unirrigated land, in the soil; within this it turns to the chrysalis and after some days emerges as a moth. The four stages can all be found on a single plant, the moth lying hidden by day and flying in the evening after dusk.

6. There are in India three distinct species of bollworm; two are called 'spotted bollworm' and are distinguishable only as moths. These bollworms are short and thick set, coloured in whity brown when young, in blotches of whitish green, black and yellow when full grown; they emerge as (1) a moth with pure green forewings (*Earias insulana*, Boisd.) and (2) a moth with buff forewings with a longitudinal band of green (*Earias fabia*, Stoll). The third bollworm is a slender caterpillar, white when young, pink when full grown. This emerges as a small dark brown moth (*Gelechia gossypiella*, Saund.). As a rule, these three species are in fairly equal number in cotton in India; a peculiar feature of the present case is that the only species common was *Earias insulana*, the two others, *Earias fabia* and *Gelechia gossypiella*, being absent or present only in normal and very small numbers. The damage to cotton was actually done by *Earias insulana* and we may neglect the other two species in discussing this outbreak.

7. The damage caused to cotton is shown in the reports of district officers. An attempt was made to estimate the actual state of things by counting the proportion of buds and bolls actually infested by bollworms in the field. Counts were made by myself

and the assistant in several places and the following figures are obtained:—

Lyallpur . . .	354	attacked out of	794	or	45	per cent.
„ (bolls only) .	187	„	708	„	69	„
Toba Tek Singh .	214	„	590	„	36	„
Multan . . .	54	„	144	„	38	„
Sargodha . . .	279	„	566	„	49	„
Palwal . . .	18	„	216	„	18	„
Karnal . . .	221	„	479	„	46	„
Rohtak . . .	68	„	223	„	24	„
Umbala . . .	136	„	283	„	48	„
Sialkot . . .	43	„	227	„	19	„
Jullundur . . .	97	„	237	„	41	„
Amritsar . . .	78	„	223	„	35	„
Lahore . . .	201	„	303	„	66	„
Muzaffargarh . .	95	„	266	„	35	„
Dera Ghazi Khan .	175	„	603	„	29	„

These figures have no relative value, but illustrate the actual work of bollworm; where, as at Lyallpur, 45 per cent. of the buds and bolls were actually infested at one time, we can realise how it was that not one bud or boll might escape and that within a week the whole number of buds might be destroyed and the plant compelled to form new ones. This shows the way in which the cotton was destroyed: as the buds formed they were eaten and fell off; the few that escaped to flower and form bolls were eaten as bolls and either fell off or opened prematurely and gave useless cotton. Casual inspection of a field showed nothing but unwonted absence of flowers and bolls; careful examination of individual buds and bolls showed the presence of bollworms in every stage of their life history and revealed how it was that such vigorous plants yielded little or no actual produce.

8. The origin of this vast number of bollworms is a matter of vital importance that may be explained quite simply. We may omit for the moment the minor bollworms and discuss only *Earias insulana*, whose increase led to the failure of cotton. When the cotton commenced to form buds, there must have been a considerable number of insects already in the fields, which as they emerged as moths coupled and the females then laid eggs on the flower buds. Before the cotton formed flower buds, the insects were in (1) the

green shoots of cotton and (2) the *bhindi* plants. The bollworm bores in the green shoots of cotton when bolls and buds are not available and can even live upon the cotton leaves, though it rarely does so. It also feeds upon the fruits and (rarely) on the stems of the *bhindi* plants (*Hibiscus esculentus*). During the months preceding the formation of the flower buds of cotton, the pest was breeding normally in these two plants. The rate of increase of the bollworm is large, if unchecked, and it is necessary to realise precisely what this is. A moth in captivity lays from 50 to 70 eggs, normally about 60. I believe a larger number is laid in the field under normal conditions, but it is safe to assume the figure 60 as the number laid. A single pair of moths emerging from their cocoons on the 1st May would produce 60 eggs. These become 60 moths about the 1st June, of which 30 are females and lay 1,800 eggs. On the 1st July there are 900 females laying eggs and they lay 54,000 eggs, which on the 1st August yield 27,000 females, laying 1,620,000 eggs. On the 1st September 810,000 female moths emerge and lay 48,600,000 eggs. This is the maximum rate of increase if none die and half are females, which all find mates. The causes which prevent this increase occurring are manifold, and it need not be supposed that such a rate of increase actually occurred: it shows, however, what the increase of a few moths may amount to under favourable circumstances. The figures are, in generations, 2 : 60 : 1,800 : 54,000 : 1,620,000 : 48,600,000. Twenty moths per acre emerging in the cotton in August would be responsible for some 18,000 bollworms per acre in the second generation that appears in the end of September: the increase therefore of twenty bollworms per acre in the cotton fields in August would have been far more than the number required to destroy every bud and boll in those fields, and it is not unreasonable to imagine that this small number occurred in an acre of cotton in August.

9. This high rate of increase is normally checked in three ways:—

(*a*) Food is not always available, and the moths have difficulty in finding plants on which to deposit their eggs so that the young may find food when they hatch.

(*b*) The larvæ are attacked by parasites which destroy them.

(*c*) The moths and larvæ are attacked by enemies, principally birds.

In the present case (*a*) the cotton, as usual, supplied abundant food when it commenced to form buds ; (*b*) parasites were markedly absent; and (*c*) excepting in the Jhelum and Chenab Colonies, birds and similar checks were probably present in normal number. The peculiar feature of the present case is the absence of parasites ; this is very marked and is a most striking circumstance. Normally, when the bollworms increase with plentiful food, their parasites increase more rapidly and keep down their numbers. The parasites are in fact the principal check on increase, and had they been present in normal quantities the bollworm would probably have been checked. I have personally examined a large number of bolls in the fields in the Jhelum and Chenab Colonies and in the Hissar District; a large number of bollworms were sent to Pusa and reared there: in almost all cases the absence of parasites has been confirmed, and I attribute the great increase of the bollworm to this fact.

10. The bollworm in India has three distinct parasites: a small ichneumon fly (*Rhogas Lefroyi*, Ashm.) which is the principal and most abundant one, increasing rapidly and destroying a very large proportion of bollworms in normal years: a yellow ichneumon, found in small numbers, which increases slowly and has little influence : a Tachinid fly (*Plectops orbata*, Wied.), which has been found only in Gujarat. Of these the yellow ichneumon was found in many places in the Punjab in very small numbers, whilst a small number also was reared from the bollworms sent to Pusa : *Rhogas* was reared only from bollworms received from Umbala, Kasur and Sialkot and was not found in the field : *Plectops* was not found at all. The most important parasite which generally checks the bollworm was, I believe, entirely absent from the majority of the cotton districts. It is impossible to account for this extraordinary feature with any positive degree of certainty. The only abnormal circumstance that I can find is the extreme cold of the preceding winter, a cold which may have destroyed *Rhogas* while leaving the bollworm. This is a bare hypothesis but one which is borne out by our knowledge of the effect of climatic changes on insect life. If we seek to account for the abnormal outbreak of bollworm, we may say that the abnormal cold almost wholly destroyed the principal check on the bollworm, so enabling the pest to increase in a manner approximating to its maximum.

11. The failure of the cotton crop in 1905 could not be averted by any practical measures, and it remains only to consider what scheme can be adopted in 1906 to avoid another failure due to bollworm. The sequence of events will probably be as follows:—The bollworms will spend the winter hibernating in the cotton fields, generally as pupæ in the cocoons, partly as numbed bollworms or moths, either on the plants, in the bolls, or in the ground. With the advent of the warm weather they will become active and the moths will emerge to fly about. The larvæ will, if food is available, continue to feed and become moths. The moths will seek for food plants on which to lay eggs and will do so on cotton or *bhindi*. If *bhindi* is available, the pest will continue to breed there until cotton is available. In the absence of parasites, there will be the same abnormal increase of the pest; if parasites are plentiful the pest will be checked. The first measure is to destroy all the cotton plants before the hibernating insects emerge; that is, before January 31st, as a safe measure with a good limit. There are then three precautions:—

(*a*) to plant no *bhindi*, so as to afford the moth no food plant,

(*b*) to plant *bhindi* as a trap crop at the same time as cotton or earlier, and destroy the bollworms;

(*c*) to introduce the parasites.

(*a*) Bhindi is grown in small quantity as a vegetable from March onwards. Even a few plants may in this case be a source of great danger, and it is advisable, if possible, to check absolutely the sowing of any *bhindi* unless it is with the express object of trapping the pest.

(*b*) *Bhindi* has been grown this year as a trap crop with cotton on the Pusa Experimental Farm. It was sown in alternate rows, with cotton, and, separately, as a border round the cotton. The *bhindi* fruited and the bollworms were found in the fruits. These fruits were removed and destroyed, while the plants were left to form new fruits. The cotton yielded freely, and whilst 4 per cent. of the bolls of the cotton were attacked, 58 per cent. of the *bhindi* pods in rows and 80 per cent. of the pods in the border contained bollworms, often several in each pod. In a check plot of the same cotton grown at a distance without *bhindi*, 21 per cent. of the bolls were infested with bollworm. The results of this experiment bear out the value of the *bhindi* plants as a trap crop, a

conclusion previously arrived at from an examination of *bhindi* plants growing in the cotton growing districts, and from a knowledge of the habits of the pest. I am of opinion that it is justifiable to act on the assumption that *bhindi* used as a trap crop will be an efficient check on the bollworm, and this is the recommendation on which I place most reliance in dealing with bollworm in 1906. *Bhindi* should be sown round the cotton fields at the rate of two seeds per *kadam* (5 feet 6 inches) and as far as possible along the borders of all fields near cotton. The more *bhindi* that is sown generally the better, provided that it is properly treated. It is possible that equally good results will follow from small compact plots of *bhindi* scattered among the cotton fields and these will be more readily looked after ; there will be less danger of plants being overlooked if this is done. As the pods mature, they must be picked off and removed ; the sound ones may be eaten, but none must be left on the plant to ripen and none must be simply picked and left lying on the ground. All must be destroyed or cooked. If *bhindi* plants are simply sown and neglected, the moth will emerge and will attack cotton if it is available. If there is danger that the pods will not be picked off it will be better to cut off the whole plants after a stated time, say in August or when the pods have grown large to ensure the bollworm in the pods being removed and destroyed.

(*c*) The introduction of the parasite can be effected by sending infested bolls to the various districts and permitting the parasites to fly away into the fields. The difficulty will be to find a sufficient number of bolls of cotton or *bhindi* pods containing parasitised bollworms ; a large number can probably be sent from the Pusa Experimental Farm, and possibly arrangements can be made to grow *bhindi* as early as possible in the Umbala or Sialkot district, with a view to supplying parasitised bollworms to other districts. The procedure would be to grow the *bhindi* as early as the season permits, sending consignments of bollworm infested pods to convenient centres. The bolls on arrival would be kept in boxes or any convenient receptacles covered with cloth; if parasites emerge from the bollworms, they may be liberated by placing the box in the open and lifting the cloth in the daytime, when the parasites will fly away and the moths will not. As an alternative the parasite breeding boxes in use in Pusa may be employed; these

consist of plain wood boxes with a sliding cover of wire gauze of a mesh sufficient to permit the parasites to escape and not the moths ; in this way the numbers of the bollworm are not increased and the parasites are readily disseminated. I am not of opinion that very much can be effected by re-introducing parasites, as the practical difficulties are very great and a larger staff would be required to do so efficiently ; it will, however, be of value in the end, and even if little can be expected this season, the parasite should be re-introduced at as many centres as possible.

12. If the cotton plants growing in January are destroyed, if no *bhindi* is sown in the summer and if *bhindi* traps are intelligently used with cotton crops, I anticipate a complete checking of the pest. It is not to be expected that this will be so thorough that all will be killed, and the degree of intelligence with which the *bhindi* traps will be used will vary. Here and there cotton will probably suffer, and in this case the cultivator may be urged to kill the pest himself ; an active and intelligent cultivator would go over his plants one by one and pick off all infested buds. After many hours spent in this work, I believe it is well within the scope of any cultivator to check his bollworm even if his *bhindi* trap fails ; the work is laborious but does not take long and good results would follow from this direct remedy if taken up vigorously.

Dusky Cotton Bug (*Oxycarenus laetus*, Kirby).

13. During my tour in the Punjab, I was struck with the great prevalence of the insect known as the Dusky Cotton Bug (*Oxycarenus lactus*, Kirby). There was an immense amount of this little insect feeding in the open bolls of cotton and destroying the seeds. The great increase of this pest is probably due to the great number of partially destroyed bolls left hanging on the plants. Normally this insect, which feeds on cotton seeds, cannot multiply very largely as the cotton is regularly picked ; the bug can feed only in open bolls and is dependent upon them for food and for the power to increase. This season so many open bolls were left on the plants that the bug found food and multiplied ; not only did it attack the damaged bolls but it infested the sound ones, and, in Hissar and Hansi for example, the seed of the cotton was picked had been to a large extent sucked out by this pest. Such seed is if

lightly attacked not of full weight, the oily matter being sucked out by the bug ; if badly attacked the seed fails to germinate and is useless. The matter affects the cultivator in two ways: his produce is lighter in weight and, selling it as lint and seed together, he loses in gross weight; a proportion of his seed is not fit for sowing either failing to germinate or giving a weak seedling. This insect is readily checked if the cultivator can be urged to pick his bad as well as his good cotton ; if, when the cotton is picked, the bad bolls were put into a bag separately and destroyed, the bug would be checked and the seed of the good bolls would not be injured. Further, bad seed can be removed very readily from the good seed if the ginned seed is "pickled," that is, rubbed with a mixture of water, cowdung and clay, and then thrown into water, when the wholly bad seed floats. This simple test separates the bad seed ; a large amount of seed thus treated has been examined seed by seed to verify this. The following figures were obtained, in each case out of 1,000 seeds. The first column shows the number that floated, the second the actual number (out of a second thousand) found bad by splitting open each seed :—

Hansi	160	...
Hissar	240	...
Jullundur	88	97
Sialkot	173	190
Umbala	181	176
Kasur	537	511

This seed was in all cases the ordinary seed obtained from ginning mills, not especially selected. I believe that better seed and more weight of produce would be obtained if the cultivators could be induced to carry out these simple measures, and I would urge that where possible they should be brought to the notice of the more intelligent of the cotton cultivators.

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