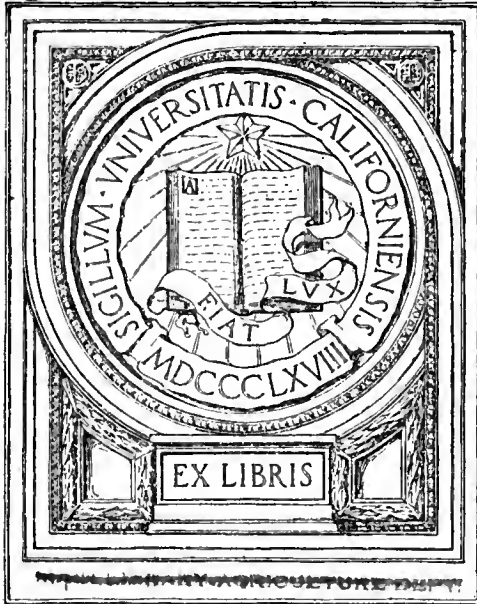


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MINISTRY OF AGRICULTURE, EGYPT.

TECHNICAL AND SCIENTIFIC SERVICE.

Bulletin No. 16.

ENTOMOLOGICAL SECTION.

THE PRESENT SITUATION
WITH REGARD TO THE CONTROL OF
THE PINK BOLL WORM
IN EGYPT,

BY

G. STOREY, B.A., Agr. Dip. (Cantab.), F.E.S.,

SUB-DIRECTOR OF THE ENTOMOLOGICAL SECTION.

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THE PRESENT SITUATION WITH REGARD TO THE CONTROL OF THE PINK BOLL WORM IN EGYPT.

The measures taken by the Ministry of Agriculture to combat the Pink Boll Worm (*Gelechia gossypiella* Saund.), have in the past raised such a storm of criticism from the general public that a statement of what has been done up to date and of the results obtained will not come amiss at the present time when a new law for the control of this pest is under consideration.

In 1916, owing to the dissatisfaction that had already been expressed with the Ministry's treatment of the pink boll worm question, the most highly qualified entomologist available, namely H. A. Ballou, Imperial Entomologist to the Department of Agriculture of the British West Indies, was asked to come and give his advice on the subject. After studying the problem for fifteen months he submitted a long and careful report in which he showed that he was in general agreement with the previously established policy of the Ministry. His recommendations, with which all the entomologists of the Ministry are in perfect agreement, may be summarized as follows:—

- (a) Earliness in ripening the crop and dealing with the old cotton plants after the last picking.
- (b) Removing and burning all green or dead bolls left on the plants after the last picking.
- (c) Treating all cotton seed immediately after ginning either by fumigation or by heat.

In the following pages the carrying out of these three recommendations is briefly discussed, their order being changed for the sake of convenience to (b), (a), (c).

CLEANING OF COTTON STICKS.

The removal and destruction of the dead bolls containing hibernating boll worms after the crop has been harvested is without doubt the most obvious of all methods of dealing with this pest. So

obvious is it that one can probably say without exaggeration that it has been suggested by every single person who has seriously studied the pink boll worm, and in Egypt it was proposed as long ago as 1873 for the purpose of controlling the common boll worm (*Earias insulana* Boisd.) by Andrea Bey, Gastanil Bey, and Ahmed Effendi Nada in a report submitted to the Council of Representatives by the Cotton Pest Committee. Accordingly, when in 1913 the pink boll worm rose to prominence as the worst cotton pest Egypt has ever known, the Ministry of Agriculture adopted boll-picking as the standard method of control and enacted Law No. 4 of 1914 by which the collection and destruction of all bolls remaining on the sticks at the end of the season was made compulsory.

In the winter of 1913-1914, owing to the late start that was made, it was practically impossible to do anything. In the autumn of 1914 the war began and again nothing was done. In 1915 a preliminary campaign was carried out, and in 1916 a stricter law was brought into force and a fairly serious effort was made to have all the cotton sticks in the country properly cleaned before being pulled up. Large quantities of cotton sticks were burnt as punishment for infringements of the law, and in spite of the opposition of cultivators in general, both large and small, a fairly high percentage of the bolls was removed from the sticks. In order to control insects which have a very rapid rate of increase, however, it is necessary to kill a very large percentage indeed in order to produce a visible effect, and at the end of the 1916 campaign, the present writer, who had control of the work in the Province of Qalyûbîya, estimated, as actually proved to be the case, that enough bolls had been left behind to carry on the infestation without appreciable diminution.

In 1917, had the campaign been carried out on the same lines, a considerable improvement in the work might reasonably have been expected owing to the greater experience of the staff of the Ministry and the increased familiarity with the work on the part of the cultivators at large. However, owing to the violent agitation against the burning of cotton sticks on account of the scarcity of fuel, this method of punishing offenders was removed and the only punishments inflicted were the fines imposed by the courts which were so ridiculously small that they had no effect whatsoever. The result was that the 1917 campaign, instead of showing an improvement, was very much less efficiently carried out than that of 1916.

Since that time the officials of the Ministry, receiving no support but much opposition from the population in general, and meeting with no thanks from any one for their ungrateful task, have expended less and less energy on the boll worm campaign, so that, although boll-picking was still compulsory by law, the number picked during

the autumn of 1919 probably did not amount to as much as ten per cent of the total.

Throughout all these campaigns the *jellahîn* showed a disastrous and increasing tendency to knock the bolls off on to the ground instead of picking them and burning them. This is undoubtedly worse than doing nothing at all, as if the bolls are left on the sticks they may be burnt before the following summer or the worms in them may be parasitized, whereas when the bolls are knocked on the ground the chances of burning are entirely removed and the chances of parasitization reduced. This practice was extraordinarily difficult to check and became so widespread that the campaigns may actually have done harm instead of good. This view is confirmed by the following facts. At the end of the 1916 campaign the present writer, judging by his own inspections and discussions with Mr. Ballou, would have put the provinces of Lower Egypt in the following order as regards the efficiency with which the cotton sticks had been cleaned. Minûfiya, Qalyûbiya, Sharqîya, Gharbîya, Daqahlîya, Beheira. The following year the average infestation during the period July 12 to September 13 was as follows :—

Minûfiya	56	per cent.
Qalyûbiya	46	„
Sharqîya	43	„
Gharbiya	35	„
Daqahlîya	38	„
Beheira	31	„

These differences may have been due to climatic or other factors as the Southern Delta has always been more heavily attacked than the Northern, but the fact remains that the boll worm in 1917 was worst in those provinces in which the cotton sticks were cleanest in 1916. It should be carefully noted, however, that this is not the same thing as saying those provinces in which most bolls were burnt.

One can say therefore with absolute justice that boll-picking as a means of controlling the pink boll worm has never been given a fair trial in the country at large. However, in order to test the effect of this control measure when properly applied, the Ministry decided in 1917 to carry out as ideal a campaign as possible in a limited area for several years in succession and by means of boll counts to watch the results. The Wâdi Tumulât, *i.e.* the cultivated area alongside the Ismailia Canal from Abu Hammâd to Qassassîn, was selected for this purpose as being well isolated from other cotton cultivation. An intensive campaign was carried out on the *gurn* system devised by Mr. Shepherd and described in Mr. Ballou's report. Under this system the cotton sticks, instead of being stripped of their bolls while still standing in the fields, are brought to a central yard or *gurn* in

which they are passed through a rake which very effectively and quickly removes all bolls and leaves.

It should perhaps be mentioned in passing that after the 1916 campaign Mr. Ballou, Mr. Shepherd (Inspector of the Province of Sharqîya), Mohammed Effendi Munîr (Inspector of the Province of Minûfiya), and the present writer, simultaneously proposed that the bolls should be removed from the sticks after, instead of before, pulling, in order to prevent the dissemination of the bolls in the fields. Most of the other Inspectors, however, strongly opposed the change on the ground that it was impossible to control what happened to the cotton sticks after they were pulled up, and it was also felt that changes in the legislation should only be made when absolutely necessary as it would be very puzzling to the *fellahîn* to have new sets of regulations every year. It was therefore decided to postpone this alteration until the result of the Wâdi Tumulât experiment was known.

In addition to carrying out the field campaign as outlined above, the Ministry supplied all cultivators in the Wâdi Tumulât with fumigated seed for sowing purposes in order to eliminate all chances of infection from this source. The campaign was repeated in the winters of 1918–1919 and 1919–1920 with perhaps increased efficiency.

The figures obtained from boll-counts in 1917, 1918, and 1919 are given in Table I, and show that the campaign of 1917 reduced the average percentage of green bolls attacked between July 12 and September 13 from 43 to 29, and that the campaign of 1918 reduced it still further to 22, *i.e.* approximately one half the figure of 1917.

TABLE I.—Wâdi Tumulât.

Date.		Percentage of Green Bolls attacked by Boll Worm.*		
		1917	1918	1919
July	12	5	4	2
„	19	18	3	3
„	26	11	7	6
August	2	20	6	10
„	9	26	15	7
„	16	27	27	6
„	23	51	39	13
„	30	86	56	37
September	6	92	52	50
„	13	92	82	87
Average		43	29	22

* These figures include all bolls which at the time of examination were, or had been, attacked by boll worms of any kind. The overwhelming majority of these worms were, of course, pink boll worms.

It should be remembered, however, that the percentage of green bolls attacked is not the same thing as the number of boll worms per 100 bolls. When only ten per cent of the bolls are attacked most or all of them will be attacked by a single worm only, but when more than fifty per cent are attacked the majority of them will contain more than one worm. For any given percentage of attacked bolls the probable number of worms per 100 bolls can be calculated mathematically, and these calculated figures have been found to agree very closely with actual fact. Thus in Table II figures actually found in experiment by Mr. Ballou are compared with figures calculated by Dr. Gough. The two sets show a remarkable similarity.

TABLE II.

Number of attacked Bolls per 100 Green Bolls.	Number of Bolls containing.						Total Number of Worms per 100 Bolls.	
	1 Worm.	2 Worms.	3 Worms.	4 Worms.	5 Worms.	6 Worms.		
50	25	13	7	3	1	1	95	Found by Mr. Ballou. Calculated by Dr. Gough.
50	25	13	6	3	2	1	97	
30	20	7	2	1	—	—	44	Found by Mr. Ballou. Calculated by Dr. Gough.
30	21	6	2	1	—	—	43	
4	4	—	—	—	—	—	4	Found by Mr. Ballou. Calculated by Mr. Gough.
5	5	—	—	—	—	—	5	

If now we take Table I and replace the number of attacked bolls by the probable number of boll worms per 100 bolls calculated as explained above, we obtain the figures given in Table III.

TABLE III.—Wādi Tumulāt.

Date.		Number of Boll Worms per 100 Green Bolls.		
		1917	1918	1919
July	12	5	4	2
	19	22	3	3
	26	12	7	6
August	2	25	6	11
	9	34	17	8
	16	36	36	6
	23	101	66	14
	30	510	132	58
September	6	600	105	97
	13	600	400	520
Average July 12 to September 13		194	78	72
Average July 12 to August 30		74	27	11

It will be seen that the average number of boll worms per 100 bolls between July 12 and August 30 was reduced by the two campaigns from 74 in 1917 to 11 in 1919, a striking testimony to the value of a boll-picking campaign when efficiently carried out. If the first two weeks of September are included for the calculation of the average the improvement is not so obvious as owing to the exceedingly rapid rate of multiplication of the pink boll worm, the number of worms present at the end of all three seasons approximated to the maximum population which can be supported by the cotton plants.

In order to arrive at the ratio of the damage done in the different years it is necessary to go one step further in our calculations since the damage done is proportional not to the number of worms per 100 bolls but to the number of worms per *jeddân* or per 100 plants. In Table IV (a) are given the numbers of green bolls per 100 trees at various dates from August 2 to September 13 which for the purposes of our present calculation may be taken as the useful bolling period. These figures are the average of seven sets of observations. From them together with the numbers of boll worms per 100 green bolls (given in Table III) we can calculate the number of boll worms in the green bolls on 100 plants as given in Table IV (b).

TABLE IV.

Date.	(a) Number of Green Bolls per 100 Plants.	(b) Number of Boll Worms per 100 Plants.		
		1917	1918	1919
August 2 ...	785	196	47	86
„ 9 ...	1,063	361	180	85
„ 16 ...	1,097	395	395	65
„ 23 ...	948	957	626	133
„ 30 ...	889	4,534	1,172	515
September 6 ...	731	4,386	768	709
„ 13 ...	520	3,120	2,080	2,704
Average... ..	—	1,993	752	614

From the above table it will be seen that the average number of worms per 100 plants was reduced in 1919 to less than one third of the number in 1917. The damage done to the crop will be proportional to the number of worms present. In 1917 Mr. Ballou calculated that 17 per cent of the crop was lost as a result of the pink boll worm attack. Therefore if we accept his figure, 614/1993 (see Table IV) of 17 per cent of the crop was lost in 1919, *i.e.* 5.2 per cent. In other words the saving amounted to 11.8 per cent of the crop, or, if we estimate the crop as 3.5 *qantârs* per *jeddân*, to 0.41 of a *qantâr* per *jeddân*, or, if we value the *qantâr* at L.E. 20, to L.E. 8.200 milliemes per *jeddân*. The two

campaigns thus resulted in a saving of cotton to the value of over L.E. 8 per *jeddân* at present prices.

The cost of these campaigns may be divided into two items : (a) the cost to the cultivators ; (b) the cost of supervision borne by the Government. The first of these has been estimated by Mr. Shepherd for the 1919 campaign as follows :—

	L.E.	M.
Compulsory pulling of sticks as opposed to cutting P.T. 50 per <i>jeddân</i> , less P.T. 25 for extra fuel so obtained	0	250
Sweeping of fields	0	500
Cleaning of sticks on rakes	0	600
Extra transport involved	0	150
	<hr/>	
TOTAL ...	1	500
	<hr/>	

It should be remarked, however, that the larger part of this sum should not be regarded as money spent but as extra labour on the part of the *jellahîn*; so that any increase in production resulting from it is pure gain to the country as a whole.

The Government expenses incurred in connection with the Wâdi Tumilât campaign amounted in 1918 to L.E. 538. For 1919 they are estimated at L.E. 730, or, since the area dealt with was 2,093 *jeddâns*, approximately L.E. 0.350 milliemes per *jeddân*.

According to the above figures, therefore, an annual campaign involving extra labour to the value of less than L.E. 2 per *jeddân* has produced an improvement in the crop to the value of about L.E. 8 per *jeddân*, a result which at first sight would seem to justify the institution of such a campaign all over the country. However, there are several strong arguments against this view. In the first place Mr. Shepherd, who was in charge of the experiment in the field, says : "The experiment proves that a campaign throughout the country on the lines of the Wâdi Tumilât is impossible, and the impossibility lies not so much in the cleaning of the sticks as in the cleaning of the fields."

Secondly, a very considerable improvement has been effected in other parts of Egypt by more economical, if less efficient, methods. And, thirdly, cultivators in general, and even the inspectorate staff of the Ministry of Agriculture, are not convinced from their own observations of the utility of the campaign. This is doubtless due partly to the difficulty of estimating accurately the degree of attack without making careful boll-counts, partly to the fact that the average person gets his general impression of the attack from the state of affairs at the end of the season when in all cases practically every boll is

attacked, and partly to the improvement in the rest of the Delta which has made the improvement in the experimental zone less obvious.

However, although one may rely with confidence on the figures given above rather than on the general impression of field observers, it would be unwise to incur the hostility of the whole agricultural population for the sake of an improvement which can only be detected by careful laboratory counts. It therefore seems advisable to give up boll-picking as a universal compulsory measure but to retain the power of enforcing it again if further experience shows such a course of action to be necessary or desirable.

EARLINESS.

Even before the common boll worm was superseded by the more dangerous pink boll worm, earliness in harvesting the cotton crop was insisted on by the Government entomologists as being of prime importance in boll worm control. Earliness in ripening means a lighter attack at the time of picking, and earliness in pulling up the plants means a lighter attack in the following season.

In Table V are given the numbers of moths which emerged from green and open bolls collected by Mr. Adair at Gemmaiza on various dates between August and October 1918. They are divided into "short-cycle" moths, *i.e.* those which emerge in the autumn and winter, and "long-cycle" moths, *i.e.* those which emerge between April and October the following year. All research to date tends to show that provided that the short-cycle moths can find no living plants on which to lay their eggs, they die without leaving any progeny. It is the long-cycle worms which, hibernating through the winter and producing moths during the following cotton season, carry on the infestation from one year to another.

TABLE V.

Date of Collection of Bolls.		Moths from 100 Green Bolls.		Moths from 100 Open Bolls.	
		Short-Cycle.	Long-Cycle.	Short-Cycle.	Long-Cycle.
August	5 ...	5	0	—	—
"	15 ...	7	1	—	—
"	25 ...	10	2	25	4
September	5 ...	22	6	8	8
"	15 ...	21	12	5	21
"	25 ...	60	46	5	27
October	5 ...	35	93	6	99
"	15 ...	27	84	6	166

The table very clearly shows, firstly, a gradual change as the season progresses from the short-cycle habit to the long-cycle habit, and, secondly, a very rapid increase in the number of long-cycle worms at the end of the season. Thus a hundred average green bolls contain no long-cycle worms at the beginning of August, six at the beginning of September, and 93 at the beginning of October. Similarly a hundred average open bolls contain four long-cycle worms at the end of August, twenty-one at the middle of September, and 166 at the middle of October. From these figures it can easily be realized that the earlier the production of bolls is stopped, *i.e.* the earlier the cotton sticks are pulled up, the fewer by far will be the number of hibernating boll worms left to carry on the infestation, and that the difference of only a few days at the critical period may make a quite appreciable difference to the attack the following year.

As already stated the attack of the pink boll worm throughout the country has been on the decrease during the past three years. Table VI gives the percentage of green bolls attacked (observed) and the number of worms per 100 plants (calculated from the last figure) at various dates in the Delta, similar to the figures given for Wādi Tumilāt in Tables I and IV.

TABLE VI.—Lower Egypt.

Date.	Percentage of Green Bolls attacked by Boll Worm.			Number of Boll Worms per 100 Plants.		
	1917	1918	1919	1917	1918	1919
July 12 ...	13	8	5	—	—	—
„ 19 ...	13	12	5	—	—	—
„ 26 ...	15	10	8	—	—	—
August 2 ...	20	13	9	196	118	78
„ 9 ...	28	21	14	415	276	170
„ 16 ...	33	28	11	527	428	132
„ 23 ...	49	38	17	910	597	190
„ 30 ...	65	42	31	1,565	685	400
September 6 ...	78	56	67	2,412	958	1,418
„ 13 ...	84	48*	88	2,444	473*	2,797
Average ...	40	—	26	1,210	—	741

The decrease in the severity of the attack shown by these figures is really very remarkable, considering that direct control measures

* These figures are too low owing to the fact that practically all the samples received during this, the last, week came from the Northern Delta where the attack is always lighter. The other samples were fairly representative of the whole Delta. Accordingly no averages have been calculated for 1918 as they would not be comparable with the other years.

have also diminished considerably during the period under review. Apart from the boll worm campaigns there are several factors which may have affected the relative abundance of the pink boll worm, namely, parasites, the weather, and changes in agricultural practice.

To deal with these in order, the very extensive breeding records of the Entomological Section give one no reason for thinking that there has been any substantial increase during the period under review in the parasitization of the pink boll worm at any given date. A number of different parasites were abundant in 1916 and even before, but have always been limited in their utility by the fact that they are unable to get at the worms until the bolls have opened.

The weather, also, is very unlikely to have had any very great effect on the pink boll worm. In the first place the weather during its breeding season, *i.e.* from June to October, does not vary very much on the average from year to year, and in any case the worm lives snugly tucked away inside the boll and is much less susceptible to changes in the weather than are external feeders. The case of the pink boll worm cannot be compared with that of the cotton worm for instance. In the case of the latter, favourable weather during October and November may give the autumn generation on the *bersim* exceptional opportunities for multiplying and lead to an exceptionally severe attack on the cotton during the following summer.

It seems probable, then, that it is to changes in agricultural practice that one must look for the causes of the decrease of the boll worm, and in Lower Egypt the only substantial change in this respect has been in earliness in pulling up the cotton plants at the end of the season.

The experiments of Mr. Cartwright (late Inspector of Gharbîya, now Director of the Higher School of Agriculture, Gîza), who showed that by reducing the watering after the middle of July he could get practically the whole of the bolls to ripen at a very early date, marked a great advance in the question of pink boll worm control. Partly as a result of these experiments, partly as a result of the direct observation of the same fact by others, partly as a result of the more general realization that it is no use keeping cotton standing after a certain date, as all late bolls are spoilt by the worm, and partly owing to the fact that Inspectors have not insisted on the bolls being picked before the sticks are pulled, the average date of the pulling of the sticks has become earlier and earlier during the past few years.

To illustrate this, one may mention that in Qalyûbîya in 1916 the pulling of cotton sticks did not become at all general till towards the end of October, about two-thirds of the total were pulled by November 20, and quite considerable quantities remained standing right through December. In 1919, on the other hand, there were

comparatively few sticks left standing at the end of October. Mr. Shepherd says, with regard to Sharqīya, "Our intensive campaign was October 1916 to January 1917. The sticks that year were probably kept standing well into December because we were trying to clean standing sticks. In 1917 there was comparatively little work done and the cutting of the sticks was probably carried out much the same as in 1916. In 1918 there was a distinct attempt made, at least in my provinces, to have them out early and the percentage of standing sticks was by the beginning of December equal to what it had been in the middle of December in the two previous years. In 1919 it was advanced a fortnight earlier still, and in addition very large quantities of sticks were off the ground by the middle of October." Thus in the past three years the average date of pulling in these two provinces has been advanced by at least a month.

Reference to Table V should convince one that this change is capable of making a very appreciable difference to the boll worm attack. Not only does earliness have a direct effect, however, in reducing the number of long-cycle worms, but it leads to a further reduction of this number in two indirect ways, namely by giving the parasites a longer period in which to attack the worms and by causing a larger quantity of sticks to be burnt before the moths begin to emerge from them.

The chief parasite of the worms in the bolls is the ichneumon fly, *Pimpla roborator* F. This insect, though it kills annually immense numbers of boll worms, is restricted in its good work, firstly by the fact that it can only get at the worms after the bolls have opened, and secondly by the fact that it ceases to breed in January. Pulling up the cotton sticks causes the green bolls on them to dry and open. A change in the date of pulling from December 1 to November 1 thus approximately doubles the period during which the worms in these bolls are exposed to the attacks of *Pimpla*.

The view that it is the earlier pulling of the sticks which has caused the reduction in the pink boll worm attack is also strongly supported by the recent history of the common boll worm in Egypt. The life-history of this insect closely resembles that of the pink boll worm except that, instead of having a long-cycle generation which hibernates right through the winter and spring, it has a continuous succession of short-cycle generations throughout the year. Consequently a long "close season" when no food-plants are available, is much more effective against it than against the pink boll worm.

Previous to 1912, in parts of the country, cotton was left standing right through the winter, being treated as a two-year crop. In 1912 this was prohibited and a date was fixed by which all cotton sticks had to be pulled or cut. From 1912 onwards, increasing areas

were devoted to Sakellarides cotton which produces much smaller second and third pickings than do the older varieties, and consequently offers much less inducement to cultivators to leave their cotton standing late. At the same time the increasing ravages of the pink boll worm in the late cotton, as we have already seen, have tended to cause earlier harvesting. The result is that whereas in 1911 quite considerable quantities of cotton were picked in December and even a little in January and cotton sticks were left standing all through the winter, in 1919, in the southern part of the Delta at any rate, picking was practically finished by the end of October and very few sticks were left standing after the middle of November.

The result of this on the common boll worm has been very marked. In 1912 samples of bolls from various localities examined by Mr. Willcocks, Entomologist to the then Khedivial Agricultural Society, were attacked to an extent varying from 11 to 44 per cent. In 1913 similar samples from the same localities showed a considerable reduction in the attack. No figures satisfactory for comparison seem to be available for 1914 and 1915, but from 1916 onwards the regular boll counts carried out by the Entomological Section show the following averages for the percentage of bolls attacked by common boll worm in the Delta during September :—

1916	...	...	...	...	...	...	4 per cent.
1917	...	...	...	...	...	...	2 „
1918	...	...	...	...	...	...	3 „
1919	...	...	...	...	...	...	3 „

From these figures it is quite clear that in the past eight years common boll worm has been reduced by changes in Agricultural practice from the position of the worst cotton pest in Egypt to one of very little importance. These changes are having a similar effect on the pink boll worm, but in order to reduce the latter to the present status of the common boll worm, it will be necessary, owing to the presence of the long-cycle worms, to advance still further the date of pulling the cotton sticks and to fumigate all cotton seed.

It is therefore recommended that the pulling up of all cotton sticks be enforced at as early a date as possible consistent with the picking of the crop. The date should be fixed for each district every year by *arrêté*.

TREATMENT OF COTTON SEED.

The third measure for the control of the pink boll worm recommended by the entomologists, was the treatment either by fumigation with poisonous gases or by heat of all cotton seed immediately after

ginning. The years 1912 to 1916 were occupied in preliminary research with a view to finding a practical method of doing this. In 1916, when satisfactory machines were found for the purpose, the erection of such machines was made compulsory in all ginneries. On account of the war, however, great difficulty was experienced in obtaining them. In the winter of 1917 to 1918 enough were obtained to treat the greater part of the seed used for sowing in Upper Egypt; in 1918 to 1919 all the seed in Upper Egypt and a small quantity in Lower Egypt was treated; and during the 1919-1920 season the whole of the seed in the country has been treated.

The two machines principally used in this work were "Simon's" and the "Delta." These are fully described in Bulletins Nos. 11 and 14. Of the former type twenty-one were erected in Upper Egypt and forty-six in Lower, while of the latter type the corresponding numbers were three and thirty-five. In addition two machines of a new type, the "Jafforti," which is very similar to the "Delta," have been erected in Lower Egypt, making the total for the whole of Egypt 107.

The percentage of worms killed by these machines as shown by the very numerous samples examined by the Entomological Section is given in Table VII.

TABLE VII.

District.	Ginning Season.	Percentage of Worms killed.*	Number of Samples examined.
Upper Egypt	1918-1919	97	6,416
Upper Egypt	1919-1920	96	4,500
Lower Egypt	1919-1920	95	15,253

All these samples were also tested for germination, during the 1919-1920 season nearly eleven million seeds being germinated, and as a result one can say absolutely definitely that if excessive temperatures, *i.e.* over 70° C., are avoided, no harm whatever is done to the germination of the seed. A few—surprisingly few—complaints have been received of bad germination in the field, but in most of these cases it was obviously due to unfavourable weather, bad cultivation, or low quality seed, and in not a single case was it definitely proved to be the result of the heat treatment.

* These figures are probably lower than the actual average owing to the fact that many more samples were taken from the smaller ginneries, which did not always work satisfactorily, than from the larger ginneries.

At the time of writing it is still too early to say what the result of this work will be in Lower Egypt, but in Upper Egypt the reduction in the attack of the pink boll worm during the past three years has been much larger than in Lower Egypt and slightly larger even than in the special campaign zone in the Wâdi Tumulât. In view of the facts that the date of pulling up the cotton plants has not been advanced to the same extent as in Lower Egypt, if at all, and that the attack has always been much lighter in Upper Egypt, it is probably only fair to give the treatment of the seed some credit for the improvement. The actual figures for the percentage of green bolls and the number of worms per 100 plants attacked are given in Table VIII.

TABLE VIII.—UPPER EGYPT (INCLUDING MIDDLE EGYPT).

Date.		Percentage of Green Bolls attacked by Boll Worm.			Number of Boll Worms per 100 Plants.		
		1917	1919	1918	1917	1918	1919
July	5	5	2	1	—	—	—
"	12	6	4	2	—	—	—
"	19	7	5	2	—	—	—
"	26	9	8	3	78	71	24
August	2	12	10	4	138	117	43
"	9	19	17	7	252	219	88
"	16	35	21	6	493	246	57
"	23	48	30	10	809	382	98
"	30	64	38	23	1,243	391	212
September	6	67	54	50	1,014	624	504
Average ...		27	19	11	569	293	147

It is therefore advisable to continue to enforce the treatment of the seed and in the new law the old regulations should remain essentially unaltered but strengthened in one or two details. Thus all cotton should be ginned before May 1, whereas under the present law unginned cotton can be kept in licensed moth-proof stores from May 1 to August 1. The object of this change is to enable the gineries to finish ginning and be properly cleaned up from all worm-infested material by May 1. At present ginning is allowed through the summer months and gineries may thus remain a source of infection to the surrounding districts. Merchants who wish to keep their cotton for speculative purposes must keep it ginned instead of unginned, and this will lessen the deterioration it normally undergoes by being kept.

Similarly a new clause should be introduced into the new law to overcome a difficulty which has hampered the carrying out of efficient work in the past. In most ginneries piles of low grade cotton, scarto, seed sweepings, and refuse from the sieves, are allowed to accumulate in the yards till the end of the season and then sold to small merchants for resifting. This material contains an immense amount of worms, many of which in the past have escaped treatment altogether. Under the new law ginneries should not be allowed to sell any material containing untreated cotton seed except in special cases to other ginneries who have the necessary apparatus for treating the seed.

CONCLUSION.

In addition to the measures discussed above which should be enforced by the new Boll Worm Law, there are still two things to be attended to by the Ministry of Agriculture and everybody interested in the welfare of the cotton crop, namely propaganda and research.

As far as propaganda is concerned the chief need with regard to boll worm control is the encouragement of methods of cultivation which tend to hasten the ripening of the bolls and of the use of early-maturing varieties. The value of both these recommendations is being appreciated more fully by the *jellahin* every year, but there is much ground yet to be covered.

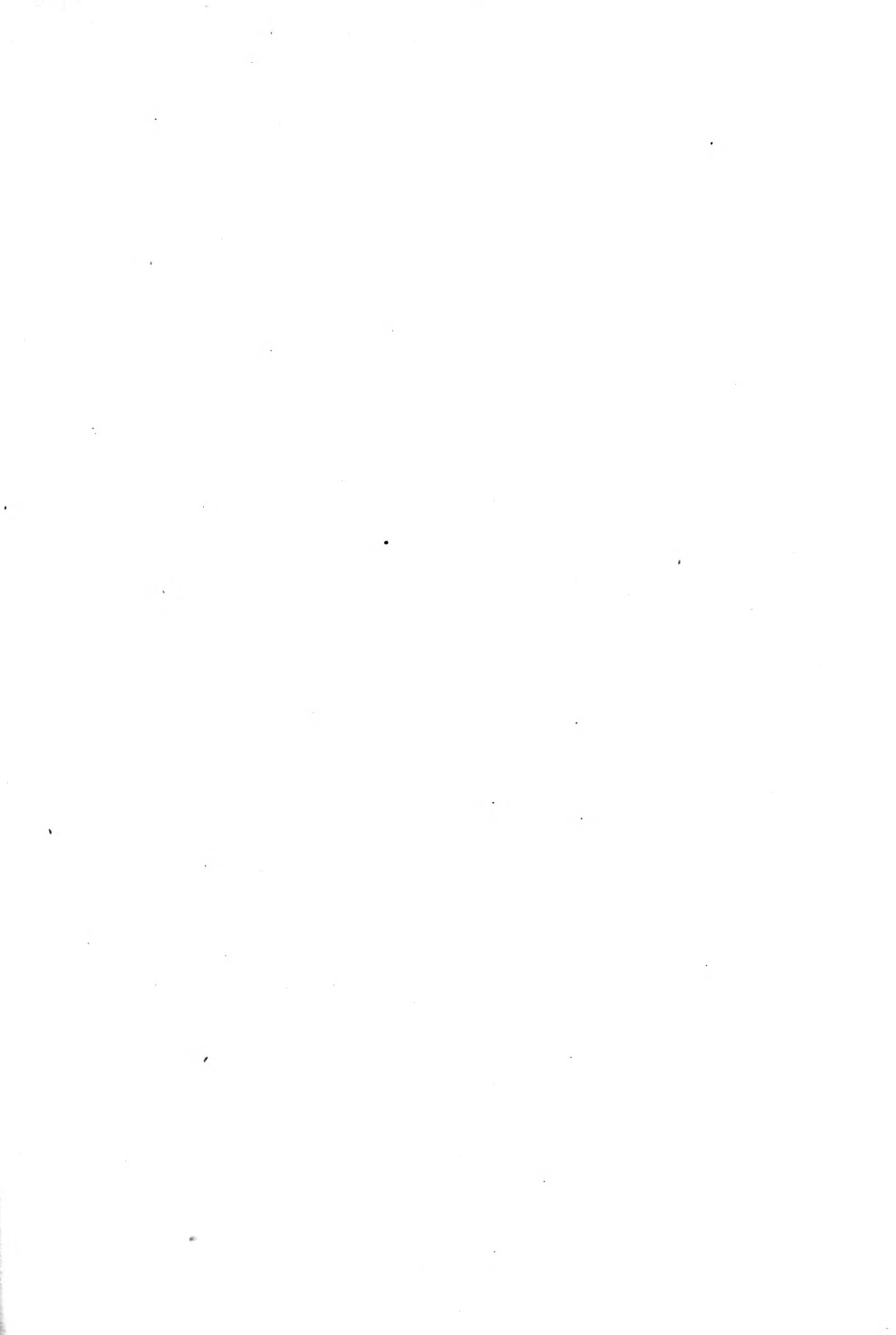
As regards research the same two points provide ample scope. The methods of obtaining the best results from early-sowing and reduced watering are by no means fully understood at the present time, and the breeding of early-maturing varieties of good quality is of immense importance and should receive adequate attention, not only from the Government, but from cultivators themselves also.

In the Wâdi Tumulât an intensive campaign was carried out during the autumn of 1919 more efficiently, if possible, than in the two previous years. During the autumn of 1920 it is proposed to leave it without any campaign at all in order to provide a control for the previous years. Careful boll counts will continue to be carried out there, as throughout the rest of the country, in order to observe the effects. It is exceedingly unlikely, however, that the attack will ever become as bad again as it was in 1917, since the cultivators will join in the general tendency towards earliness, they will have nothing but fumigated seed for sowing, and they will probably do a certain amount of work on the lines of the campaign from sheer force of habit.

In Upper Egypt the damage done during 1919 was practically negligible. In Lower Egypt the damage, although less than pre-

viously, was still greater than it has ever been in Upper Egypt. During the current (1920) season it is probable that in Upper Egypt it will be much the same as last year, and in Lower Egypt, owing to the unprecedented earliness in the pulling of the cotton sticks, together with the treatment of the seed, it should be less than it has ever been since 1913 when the pink boll worm attained the position of Egypt's premier cotton pest.

In conclusion an expression of thanks is due to many members of the staff of the Ministry of Agriculture, notably Dr. L. H. Gough, Mr. J. D. Shepherd, and Mr. E. W. Adair, all of whom have done at least as much as the present writer towards the collection of the facts presented in this paper.



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