MEALYBUG AND ITS EFFECT ON SUGARCANE

By J. DICK.

Almost every field of sugarcane in Natal, as in most other sugar-growing countries, harbours populations of the mealybug, *Trionymus sacchari*, Ckll. For several years investigations, aimed at determining to what extent these insects affect the development of the cane, have been in progress at the Experiment Station. Although this work can not be regarded as completed, it is thought desirable at this stage to publish an account of the information so far obtained.

Effect on Germination of Setts.

An experiment described in 1942[6] showed that the presence of mealybugs on setts of Co.290 led to significantly poorer germination. Subsequent pot tests with Co.281 and N:Co.310 were somewhat inconsistent, the figures in Table I being representative of the type of result obtained. In this experiment setts, with or without mealybugs, were planted in tins, half of each batch being washed in water before planting. Fifteen single-budded setts were planted in each tin, and germinated buds were counted (on 26th September, 1950) five weeks after planting.

TABLE I.

Number of buds germinating.

N:Co.310				Co.281			
Mealy-bug	Mealy-bug washed	Unin-fested	Unin-fested washed	Mealy-bug	Mealy-bug washed	Unin-fested	Unin-fested washed
11	11	12	11	12	13	14	13
12	10	13	13	12	13	15	14
14	13	11	12	11	14	15	14
12	10	13	13	12	15	15	15
12	12	14	15	11	15	15	12
9	7	11	15	12	14	15	15
70	63	74	79	70	84	89	83

Required differences: 9.2 at 19 to 1; 12.3 at 99 to 1.

These figures show a significant depression only for the washed "mealybug" setts in N:Co.310 and for the unwashed "mealybug" setts in Co.281. However, if the results for the two varieties are combined, the totals are: mealybug 140; mealybug washed 147; uninfested 163; uninfested washed 162. It is doubtful whether statistical analysis of the figures, in this form, is justified but calculation shows required differences of 14.4 at 19 to 1 and 19.4 at 99 to 1, indicating significant depression in germination in both mealybug and washed mealybug setts for the two varieties together.

Residual Effect on Germination.

The mealybugs secrete a covering of wax, and also produce a syrupy "honeydew" on which a black, sooty mould usually develops. Cane which has been infested with mealybugs can thus almost always be identified by the presence of wax and sooty mould, even when the insects have disappeared. In an attempt at gaining information on any possible residual effect of mealybug infestation, an experiment was carried out in which cane of the varieties N:Co.310, Co.281 and Co.301, with and without these symptoms, was planted in tins. Six replications were planted for each treatment, and each tin received twelve single-budded setts. Germinated buds were counted (on 23rd June, 1951) six weeks after planting; the results are given in Table II.

TABLE II.

Number of buds germinating.

C — clean setts.

XM — setts showing symptoms of previous mealybug infestation.

N:Co.301		Co.281		Co.301	
XM	C	XM	C	XM	C
3	9	9	11	6	12
2	9	10	10	9	11
1	7	10	9	8	12
2	8	8	10	7	10
4	7	6	10	7	11
3	6	7	9	7	11
15	46	50	59	44	67
Differences:					
31		9		23	

Required differences: 8.5 at 19 to 1; 11.5 at 99 to 1.

These figures indicate a significant residual effect in all three varieties, the effect on Co.281 being, in this instance, less significant than that on the other two varieties.

During investigation of a case of bad germination in N:Co.310 at Compensation, it was thought that mealybug infestation might have been a factor to be considered. The field from which plant material had been derived was inspected, and most of the cane showed symptoms of having been infested, although the insects had disappeared. Cane with and without these symptoms was collected from this field and planted in tins, twelve single-budded cuttings being placed in each tin. The germinated buds were counted (on 14th May, 1951) five weeks after planting; the figures obtained are given in Table III.

TABLE III.

Number of buds germinating.

N:Co.310	
With mealybug symptoms	Without mealybug symptoms
8	9
7	7
7	8
7	7
6	8
8	6
—	—
43	45

These figures do not indicate any residual effect in this instance, and poor germination was probably due to some other factor.

Field Experiments.

A field trial was planted at the Experiment Station at the beginning of November, 1950, in 36 plots, each consisting of 4 lines, 4½ feet apart and 16 feet long. A line between plots was left blank, and a break 9 feet wide was left between banks of plots to delay, as far as possible, the spread of mealybugs from one plot to another. The soil in the breaks and in the blank lines was watered with an emulsion of sheep-dip in an attempt at preventing the spread of mealybugs by ants.

Three varieties of cane were planted, namely N:Co.310, Co.281 and Co.301. For each variety, clean setts and setts infested with mealybugs were selected from the same field, an attempt being made at obtaining planting material with as nearly as possible the same degree of infestation for each variety. Only the top sett, about 18 inches long, was taken from each stick. No fungicidal treatment was employed, and the cane was planted end-to-end (single stick) the trash being left on the setts to avoid disturbing the mealybugs. For each variety, six plots were planted with clean and six with infested setts.

Reliable information on the effect of mealybugs on germination was not available from this experiment, as it was found difficult to distinguish, in the field, between primary and secondary shoots. Obvious differences in the total numbers of shoots produced in the "clean" and "mealybug" plots were, however, noticed and counts were therefore made, at monthly intervals, of the total numbers of shoots which developed. These counts were continued until, about six months after planting, counting became impracticable.

The greatest relative difference in numbers of shoots between "clean" and "mealybug" plots was found three months after planting, the results being shown in Table IV.

TABLE IV.

Numbers of shoots—three months after planting.

N:Co.310		Co.281		Co.301	
Mealybug	Clean	Mealybug	Clean	Mealybug	Clean
114	373	175	318	95	386
173	365	194	329	107	567
174	276	216	265	173	455
179	339	202	339	181	530
95	207	102	248	225	463
147	208	139	156	228	285
882	1768	1028	1655	1009	2686
Differences:					
886		627		1677	

Required differences: 429 at 19 to 1; 580 at 99 to 1.

At this stage, some cane of each of the three varieties, which had been planted at the same time and under the same conditions as the experiment, was dug up and examined. In the plots grown from infested setts, the insects were found to have disappeared from the setts themselves, but young mealybugs, presumably of a new generation, were found clustered at the bases of the primary shoots. It was thought that the presence there of these insects might have been responsible for the poorer development of secondary shoots. Plants from "clean" setts were still free of mealybug.

For comparison with Table IV, the figures in Table V show the numbers of shoots counted five months after planting.

TABLE V.

Numbers of shoots—five months after planting.

N:Co.310		Co.281		Co.301	
Mealybug	Clean	Mealybug	Clean	Mealybug	Clean
338	634	435	572	262	667
439	545	448	572	255	820
394	493	447	448	409	700
416	537	427	559	390	662
289	439	336	531	509	672
421	421	350	361	468	514
2297	3069	2443	3043	2293	4035
Differences:					
772		600		1742	

Required differences: 587 at 19 to 1; 794 at 99 to 1.

It will be noticed that, although the total difference between "mealybug" and "clean" plots has been maintained, the relative difference has decreased with further development of shoots in both series. It will also be noticed that the differences for Co.301 were considerably higher than for the other two varieties. Statistical analysis of the figures showed that this difference in response between the varieties was significant (at 19 to 1).

Apart from these differences in numbers of shoots, there were obvious differences in growth, the plants grown from clean setts being considerably better developed than those from infested setts. In this respect also, Co.301 was more severely affected than the other two varieties. Although no numerical data are available to demonstrate this difference in growth the difference, for Co.301, is illustrated in the photograph, Fig. 1.

Figure 1.
Co.301, six months old; that on the right grown from setts infested with mealybugs, that on the left from clean setts.

In spite of attempts at preventing the spread of mealybugs between plots, all the cane in this field became slightly infested at the age of about eleven months. Apparent differences in growth, however, persisted for some time after this.

The crop from this experiment was harvested in July, 1952. The cane from each plot was weighed, the sticks of millable cane were counted, samples from each plot were analysed by the staff of the Chemical Department, and the weight of sucrose per plot was calculated. The information is shown in Tables VI, VII and VIII. The weights of cane and sucrose are given in pounds per plot. Calculation of the results as tons per acre is not justified, since each plot was surrounded by breaks, and the yield was considerably higher than would have been expected if the cane had been continuous.

TABLE VI.

Weight of cane in pounds per plot.

N:Co.310		Co.281		Co.301	
Mealybug	Clean	Mealybug	Clean	Mealybug	Clean
1145	1419	950	929	920	1082
1283	1193	923	1000	855	1347
1182	1218	902	942	1071	1190
1242	1467	987	971	1006	1281
1242	1196	818	896	1242	1146
1147	1157	788	818	1251	1257
7241	7650	5368	5556	6345	7303
Differences:					
409		188		958	

Required differences; 907 at 19 to 1; 1227 at 99 to 1.

As far as weight of cane per plot was concerned, there was thus a significant difference between "clean" and "mealybug" plots only for Co.301.

TABLE VII.

Sucrose in pounds per plot.

N:Co.310		Co.281		Co.301	
Mealybug	Clean	Mealybug	Clean	Mealybug	Clean
186	221	148	146	137	144
199	200	139	160	128	196
178	199	137	144	153	189
205	223	152	149	164	189
204	199	122	138	195	169
182	166	122	127	180	182
1154	1208	820	864	957	1069
Differences:					
54		44		112	

Required differences: 128 at 19 to 1; 170 at 99 to 1.

For sucrose yield there was thus no significant difference between "clean" and "mealybug" plots, although the figures for Co.301 approached significance.

TABLE VIII.

Numbers of sticks of millable cane.

N:Co.310		Co.281		Co.301	
Mealybug	Clean	Mealybug	Clean	Mealybug	Clean
324	401	417	411	329	389
381	372	400	389	381	431
381	340	382	389	371	408
363	330	372	418	382	455
368	375	368	436	451	396
363	341	377	374	465	436
2180	2159	2316	2417	2379	2515
Differences:					
—21		101		136	

Required differences: 225 at 19 to 1; 304 at 99 to 1.

There was thus no significant difference in numbers of sticks of millable cane between the "clean" and the "mealybug" plots. Comparison of the above figures with Table V shows that, for the "mealybug" plots, the numbers of sticks of millable cane at the time of cutting correspond reasonably closely to the numbers of shoots present at five months after planting, whereas, for the "clean" plots, the numbers of sticks of millable cane are considerably lower than the numbers of shoots present at five months. In other words, in the "clean" plots a considerable proportion of the shoots failed to reach maturity. It is considered possible that, in this instance, the depressing action of the mealybugs kept the numbers of shoots within the saturation limit for the field, while the "clean" plots were able to produce shoots in excess of this limit. The possibility still exists that, under different growing conditions, a greater difference between "clean" and "mealybug" plots might be found at the time of harvesting.

Second Field Experiment.

The object of the second field experiment, which was planted in December, 1951, was to determine whether the depressing effect of mealybug infestation on early development would persist after the insects themselves had been removed. The plots were of the same number and size as in the first experiment, and cane of the same varieties was planted. Infested and uninfested setts were selected, the top of each stick, again, being the only portion used. In this experiment, however, the setts were trashed, and both uninfested and infested setts were washed in water to remove all the insects before planting. Counts of the numbers of shoots developing were again made, the numbers present five months after planting being shown in Table IX.

TABLE IX.

Numbers of shoots—five months after planting.

N:Co.310		Co.281		Co.301	
Mealybug washed	Uninfested washed	Mealybug washed	Uninfested washed	Mealybug washed	Uninfested washed
561	569	456	462	585	677
490	594	488	408	579	670
585	606	530	580	525	735
641	711	561	571	625	726
626	618	527	601	635	716
540	676	546	594	577	701
3443	3774	3108	3216	3526	4225
Differences:					
331		108		699	

Required differences: 267 at 19 to 1; 362 at 99 to 1.

The differences between "uninfested washed" and "mealybug washed" plots were thus significant for Co.301 and N:Co.310, although not as great as when the cane was not washed. This demonstrates some residual effect from mealybug infestation. However, obvious differences in the size of the cane such as were found, particularly with Co.301, in the first experiment were lacking, and it is not expected that any significant differences will be found when this cane is harvested.

Inoculation Experiments.

A sucking insect may influence the growth of a plant either directly, by the mechanical effects of its puncture and the removal of juice, or indirectly, by the injection of some harmful substance, which may be either a pathogen or a toxin. To discover whether injury caused by the sugarcane mealybug might include injection of harmful substances, several experiments have been carried out involving inoculation of cane with the body-fluid of the insects.

In the first experiment, single-budded cuttings of N:Co.310, Co.281 and Co.301 were injected with an extract prepared simply by expressing the contents of the insects through muslin. This extract was not treated in any way, apart from dilution with twice its volume of distilled water, which was found to be necessary in order to make it sufficiently fluid to pass through a hypodermic needle. Each sett was inoculated with approximately 0.2 cc. of the liquid before planting. A second series of setts was injected with distilled water to enable any effects of mechanical injury to be eliminated from the results, and a third series was left untreated. The setts were planted in tins (on 17th January, 1951) each tin receiving twelve single-budded setts.

After four weeks, the numbers of buds which had germinated were counted; the results are shown in Table X.

TABLE X.

Numbers of buds germinating.

C = Untreated setts.
W = Setts injected with distilled water.
M = Setts injected with mealybug body-fluid.

N:Co.310			Co.281			Co.301		
M.	W.	C.	M.	W.	C.	M.	W.	C.
5	6	10	8	12	12	2	11	12
5	11	8	9	12	11	1	12	11
6	6	9	7	12	11	1	12	11
7	8	5	10	12	12	2	10	12
2	10	9	10	11	12	2	12	11
7	7	9	7	12	12	1	10	12
32	48	50	51	71	70	9	67	69

Differences (least):
16 19 58

Required differences: 9.6 at 19 to 1; 12.8 at 99 to 1.

These figures appear to indicate a significant depressing effect produced by inoculation with the body-fluid of mealybugs in all three varieties. The effect on Co.301 is apparently more severe than on the other two varieties.

As this preliminary trial had indicated significant results, an experiment was carried out to test the effect of inoculation of setts with mealybug body-fluid treated in various ways, in an attempt at discovering whether the effect was due to a pathogen or a toxin. The variety Co.301 was used, and one series of setts was inoculated with fluid prepared from mealybugs which had been surface-sterilized with formalin to destroy any organisms which they might be carrying externally. Other series were inoculated with untreated fluid or with fluid which had been autoclaved or filtered through a bacteriological filter. Untreated setts and setts injected with distilled water were also planted. Six tins, each with twelve single-budded setts, were planted for each treatment. Counts of germinated buds were made (on 2nd May, 1951) four weeks after planting; the figures obtained are shown in Table XI.

TABLE XI.

Numbers of buds germinating—Co.301.

C = Control (untreated).
W = Injected with distilled water.
M = Inoculated with untreated mealybug fluid.
A = Inoculated with autoclaved mealybug fluid.
F = Inoculated with filtered mealybug fluid.
S = Inoculated with fluid from surface-sterilized mealybugs.

C.	W.	M.	A.	F.	S.
11	11	10	8	5	11
8	9	11	11	10	11
9	11	10	12	7	9
7	9	11	11	8	12
11	10	11	8	7	12
9	10	10	11	8	11
55	60	63	61	45	66

As no valid conclusions could be drawn from this set of figures, the experiment was repeated during the following September but, in this instance also, no significant results were obtained.

Discussion.

The ability of sucking insects to produce disease symptoms in plants, without the presence of a pathogen, has been recognised in a number of instances. Thus, Williams[7] and Withycombe[8] have concluded that froghopper blight of sugarcane is caused entirely by the feeding of *Tomaspis saccharina* Dist. and not by fungi, bacteria or viruses transmitted by this insect. Similarly, mealybug wilt of pineapples has been studied, particularly by Carter,[1-5] and has been shown to be due to the feeding of *Pseudococcus brevipes* Ckll. and not to a pathogen transmitted by this insect, although some of the symptoms of mealybug attack on pineapples were thought[4] to be due to toxins secreted by symbiotic bacteria within the body of the mealybug.

Carter[3] has proposed the term "toxicogenic" for insects which are able to cause diseases by the injection of toxic substances. Among such toxicogenic species, not all individuals may be capable of producing toxic symptoms; moreover, individuals may be able to produce such symptoms only at certain times. Individuals of toxicogenic species, when they are able to produce toxic symptoms, are, therefore, distinguished at "toxiniferous."

As far as the sugarcane mealybug is concerned, evidence so far available is too slight for the conclusion to be drawn that this species is toxicogenic. However, the depressing effect on early growth caused by infestation of the setts appears to have been proved, and the persistence of at least part of this effect, when the insects have been removed, suggests that the direct effect of feeding is not the only factor involved. If the result of the first inoculation experiment is valid, the hypothesis can be suggested that the insect is toxicogenic. The negative results in other experiments would then be due to its not always being toxiniferous. Further investigations on these lines are contemplated.

Acknowledgments.

My thanks are due to the Field Staff of the Experiment Station, particularly to Mr. F. Almond for supervising the planting and harvesting of field experiments; also to the Staff of the Chemical Department for analysis of cane samples.

Summary.

The results are given of a number of experiments on the effects of infestation by the sugarcane mealybug. It is shown that the presence of mealybugs on setts at the time of planting has a detrimental effect on early growth. This is indicated by the numbers of shoots developed as well as by their size. Some part of this effect may persist, even if the insects are removed before planting, which suggests that the mechanical effects of feeding are not the only factors involved. Experiments on the inoculation of cane setts with body-fluid extracted from mealybugs have given inconsistent results.

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Mr. Dymond congratulated Dr. Dick on his paper. He said that he did not think anybody could say that there had not been variety in the papers presented to Congress. He felt that nobody could call himself a sugar man until he had taken on the chairmanship of the Association and had had to concentrate on the various types of papers that were presented.

Dr. McMartin said that this experiment of Dr. Dick's provided an example of an insect which was taken very much for granted as having no appreciable effect on growing cane. Agriculturally it had been ignored, although some effect had been previously found on milling. The figures showed that it might be possible to introduce a variety of cane which could be affected by the mealybug. He asked whether the incidence of mealybug was greater or less today than it was in the days of Uba.

Mr. Dymond said he felt that the incidence was very much lower. It was necessary today to look for mealybug, whereas in the days of Uba they could be found almost anywhere. In his view, they formed one of the greatest difficulties in clarifying Uba juice.

Dr. McMartin said that in the South African Sugar Journal of many years ago there was reference to a "gummy disease" in the Chaka's Kraal district. He wondered whether this was due to the effect of mealybug, or whether it was the disease known as gummosis. This disease existed in Mauritius from which many canes had come to South Africa and he felt it might have been introduced. Many of the older varieties were reported to have become gummy and he wondered whether this might have been due to the greater incidence of mealybug.

Mr. Dymond said that with the older varieties of cane after rain there was a swelling and a gummy material formed on the cane, which was due to mealybugs.

Dr. Dodds said that he noticed Dr. Dick had recorded the presence of mealybug clustering round the base of young shoots. He thought this was unusual, as in the majority of cases the mealybugs were found clustered near the top of the shoot. He referred to Louisiana experience where mealybugs of a different species from ours, however, were found near the base of the shoot, which was contrary to Natal findings. It was found in Louisiana that the principal detrimental effect of mealybug on the cane was to depress the purity of the juice at the mill, probably because due to the short growing season in Louisiana the juice purity was already uneconomically low. The only serious effect of mealybugs, as far as Natal was concerned, was apparently in the filtration of the juices. Otherwise there appeared to be no significant injury caused by mealybug in its present numbers.

Dr. Dick said the mealybug found in Louisiana was different from that found in South Africa. The existence of mealybugs at the base of primary shoots in the instance quoted was due to the fact that the growth was comparatively small and the cane itself was not more than 18 in. high.

Mr. Rault confirmed what Mr. Dymond had said about the incidence of mealybug being greater in the days of Uba. He could remember that in the early twenties the manufacturing processes such as filtration and crystallisation were adversely affected by higher viscosity than at present, due to a large proportion of sticky substances in the nature of waxes and gums. Mr. Dymond at that time had suggested the mealybug as the agent responsible for such viscous substances. Clarification processes were at present more thorough and more chemicals were also used. Wax determination on the filter cake of all South African factories had given him, at that time, a much higher percentage than at present.

Mr. Dymond asked that a vote of thanks be accorded to Dr. Dick for his most interesting paper.