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A REPORT OF SOME INVESTIGATIONS ON THE CORN INSECTS OF PUERTO RICO

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During the period August 1935 to June 1936 studies were made by the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture on insects attacking growing corn in Puerto Rico. These studies were financed from a special fund provided by the Department for the purpose and were conducted in cooperation with the experiment station of the United States Department of Agriculture at Mayagüez and the substation of the Agricultural Experiment Station of the University of Puerto Rico at Isabela.

As a result of these studies the following four species of insects were determined to be of prime economic importance to the corn crop of Puerto Rico: The corn leafhopper (*Peregrinus maidis* Ashmead), the otitid (ortalid) fly *Euxesta stigmatias* Loew infecting the ears, the fall armyworm (*Laphygma frugiperda* (A. and S.)), and the corn earworm (*Heliothis armigera* (Hbn.)). The corn leaf aphid (*Aphis maidis* Fitch) and the sugarcane borer (*Diatraea saccharalis* (F.)) were found in varying numbers, but little damage by them was noted. Control experiments were conducted with the fall armyworm and the corn earworm.

Because of the tropical climate and the varied topography of the island, there is wide variation in rainfall, this ranging from 30 to over

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100 inches annually in different locations. The average variation between mean summer and mean winter temperatures is about 5 Fahrenheit degrees. Corn can be grown at all seasons of the year in locations where there is sufficient rainfall, and can be grown at any time in those areas that have been adapted to irrigation. Therefore corn in all stages of development can be found at any time. There was also found to be a great overlapping of the generations of corn insects, as eggs, young in all stages of development, and adults could be found at the same time in the same field.

THE CORN LEAFHOPPER

Peregrinus maidis Ashmead

In a survey of the island made in September and October 1935 no field was found in which the corn leafhopper was not present, and little difference in abundance was noticed in the different sections of the island. Fields averaged from 5 to 83 percent of the plants infested. Large numbers of these insects develop in the whorls of young plants and around the ear buds of older plants. Their feeding causes many young plants to wither and die, but the damage to older plants is not apparent. The greatest importance of the corn leafhopper is in the fact that it is the vector of corn yellow stripe disease, to which native varieties of corn are resistant but the exotic varieties very susceptible.

Euxesta stigmatias Loew

The larvae of the dipteron *Euxesta stigmatias* were found infesting the ears of corn in the roasting-ear stage. A large majority of the ears in fields in all sections of the island were infested. The eggs of this fly are deposited on the silks of the ears. The young larvae hatch in 2 to 4 days and feed for a short time in the silks, later working down into the developing grain. The tips of many ears are damaged and often entire ears are destroyed. The greatest damage probably consists in the unsightly appearance and malodorous condition imparted to roasting ears. The fly may pass through a complete generation in 18–24 days. Certain observations on this insect were presented in a previous publication.[2]

[2] App, Bernard A. *Euxesta stigmatias* Loew, an Otitid Fly Infesting Ear Corn in Puerto Rico. JOUR. AGR. UNIV. PUERTO RICO 22 (2) : 181–188, illus. 1938.

THE FALL ARMYWORM

Laphygma frugiperda (A. and S.)

The larvae of the fall armyworm were found to be abundant in all sections of the island and present at all seasons. The eggs of this insect are laid in a mass on the leaves of young corn plants. The newly hatched larvae feed on the leaves, later moving into the whorl, where they consume a large quantity of leaf surface, often destroying the entire whorl and killing the plant. Eggs are also deposited on older plants and the developing larvae feed in the young ears, often entering from the side and between the leaf sheath and the ear. The average developmental period for 53 individuals raised in the laboratory from egg to adult was 35.6 days, so it is believed that many generations occur in a single year. Many larvae of this insect were observed to develop on malojillo grass (*Panicum purpurascens* Raddi), and severe damage was noticed in a field of corn that had previously been in grass. In this field the partly grown larvae attacked the young corn in cutworm style.

CONTROL MEASURES

Poisoned Bait.—In the case of partly grown larvae attacking corn after the manner of cutworms, an application of standard poisoned-bran bait gave good results. Paris green was used as the toxic agent in the bait.

Dusts.—Three different experiments were conducted to test the effectiveness of dusts for the control of the fall armyworm. All were applied with a large plunger-type hand duster having a short extension pipe ending in a fan-shaped attachment that directed the dust into the whorl of the young plants. About 8.5 pounds of dust per acre was required for small plants and as much as 18 pounds per acre for larger plants. In November 1935, at Mayaguez, four different dusts were tested in a randomized block arrangement replicated four times. Each plot was 10 by 15 hills in size and averaged about 1,000 plants per treatment. Three applications were made at 10-day intervals beginning November 9, when the plants were about 15 days old, and ending November 29, after which time it was thought that further dusting was impractical. Infestation counts were made on December 10, 1935, and the results are shown in table 1.

Because of the low percentage of control obtained in the previous test some changes were made in the experiments conducted during March

TABLE 1. *Efficacy of various dusts for the control of the fall armyworm. Mayagüez, P. R., November–December 1935*

TREATMENT	PLANTS	PLANTS INFESTED	CONTROL [1]	PLANTS BURNED
	Number	*Percent*	*Percent*	*Percent*
Lead arsenate and talc 1 : 4	1,116	31.0	53.5	19.9
Lead arsenate and talc 1 : 9	1,049	32.7	51.0	17.4
Pure dusting sulfur	973	59.0	11.5	0
Derris and talc 1 : 4	1,054	65.7	1.5	0
Check	1,051	66.7	—	—
Required significant difference for odds of 19 to 1		8.00		
Required significant difference for odds of 99 to 1		11.22		

[1] Percent controls computed from the formula $\frac{X - Y}{X} \times 100$, where X equals the percent infested in the check plots and Y equals the percent infested in the treated plots.

and April 1936. Experiments were conducted at Mayagüez and Isabela, and were each replicated 5 times. The plots at Mayagüez were 5 by 15 hills in size, totaling about 370 plants per treatment. At Isabela, where the corn was planted in drill rows, the field was divided into five blocks subdivided into plots running the length of the field. Treatments were applied to a single row in each plot. A buffer row of untreated corn was left on each side of the treated row. Each treated row contained about 140 plants, making approximately 700 plants per treatment. Dusting was done at weekly instead of 10-day intervals and was continued until the plants began to tassel. Sulfur was omitted from this test because it had failed to show significant results in the November-December trials and because of its high cost in Puerto Rico. The lead arsenate in the proportion of 1 part to 4 of talc was also omitted, since the results obtained in the previous experiment were no better than those obtained with the mixture with less arsenate. Derris was included but made slightly stronger by using 3 parts of talc to 1 of derris (4 percent rotenone) to give about 1 percent of rotenone in the dust. Barium fluosilicate in the proportion of 1 part to 9 of talc, and magnesium arsenate at the same dilution, were included in these tests. Table 2 shows the results of the tests at Mayagüez and Isabela during March

and April. In these trials the dusts were applied at weekly intervals, at Mayagüez beginning March 18 and ending April 15, and at Isabela beginning March 23 and ending April 13.

An analysis of the variance of the three experiments for the control of the fall armyworm is given in table 3. All three experiments showed some highly significant differences among the treatments. The required differences necessary for two means to differ significantly were computed and recorded in tables 1 and 2. In table 1 it is seen that there were no real differences between the results with derris and with sulfur and in the check. The two mixtures of lead arsenate show highly significant differences from the check but do not differ significantly from one another. In the experiments at Mayagüez and Isabela completed in June 1936 all the treatments show a highly significant difference from the check with lead arsenate, showing a significant advantage over the other materials. The somewhat better control obtained in April may be due to dusting at weekly rather than at 10-day intervals. All mixtures of lead arsenate burned some of the plants, but no serious damage occurred. Barium fluosilicate burned the plants rather severely, killed some of them, and appeared to stunt the growth of others.

TABLE 2. *Efficacy of dusts for the control of the fall armyworm, Puerto Rico, March–April, 1936*

TREATMENT	EXPERIMENT AT MAYAGÜEZ				EXPERIMENT AT ISABELA			
	PLANTS	PLANTS INFESTED	CONTROL	PLANTS BURNED	PLANTS	PLANTS INFESTED	CONTROL	PLANTS BURNED
	Number	*Percent*	*Percent*	*Percent*	*Number*	*Percent*	*Percent*	*Percent*
Lead arsenate and talc 1 : 9	392	8.4	88.2	25.6	753	22.8	70.6	35.7
Barium fluosilicate and talc 1 : 9	376	23.9	66.4	32.5	713	35.8	53.9	64.7
Derris and talc 1 : 3	371	38.2	46.3	0	745	49.9	35.7	0
Magnesium arsenate and talc 1 : 9	383	58.2	18.3	0	714	60.3	22.3	0
Check	359	71.2	—	—	714	77.6	—	—
Required significant difference for odds of 19 to 1		8.40				8.12		
Required significant difference for odds of 99 to 1		11.57				11.19		

TABLE 3. *Analysis of variance of the efficacy of dusts for the control of the fall armyworm in Puerto Rico, 1935–1936*

SOURCE OF VARIATION	LOCATION AND DATE OF EXPERIMENTS					
	MAYAGÜEZ NOVEMBER 1935		MAYAGÜEZ APRIL 1936		ISABELA APRIL 1936	
	DEGREES OF FREEDOM	MEAN SQUARE	DEGREES OF FREEDOM	MEAN SQUARE	DEGREES OF FREEDOM	MEAN SQUARE
Blocks.....	3	17.03	4	78.20	4	189.85
Treatments.	4	1,262.24*	4	3,198.50*	4	2,259.27*
Error.....	12	26.98	16	39.22	16	36.65

* Highly significant.

THE CORN EARWORM

Heliothis armigera (Hbn.)

Earworms were found to be abundant in Puerto Rico and usually were infesting a large percentage of the ears. In the survey of corn insects made in August and September 1935 no field of corn in the ear stage was found in which this insect was not present. Considerable damage was also noticed to peppers and tomatoes. In the examination of several tobacco fields no earworms were noted. Some observations on the percentage of ears infested with earworms on different dates during the year are given in table 4.

TABLE 4. *Percentage of ears found infested with larvae of the corn earworm in various fields at different seasons in Puerto Rico*

DATE	LOCATION	EARS INFESTED
		Percent
1935		
August 19	Mayagüez	52.0
August 19	do.	81.0
September 23	Isabela	39.0
September 23	Hatillo	75.0
October 14	Mayagüez	56.0
October 14	Isabela	69.0
November 6	do.	43.0
1936		
January 8	Lajas	87.0
February 3	Mayagüez	27.8
May 11	Isabela	61.4
June 1	Mayagüez	55.5
June 5	Isabela	46.9

CONTROL EXPERIMENTS

Three experiments were conducted to test different methods of control for the corn earworm under Puerto Rican conditions. A randomized block arrangement was used in these experiments, the first, completed in February 1936, replicated four times, and the later experiments, completed in June 1936, replicated five times. A tropical sweet corn USDA–34, developed at the experiment station at Mayagüez, was grown for the tests. In the tests at Mayagüez and completed in February, each plot was 5 by 15 hills in size and averaged about 175 ears per treatment of four replications. In the trials completed in June 1936, plots at Mayagüez were 6 by 15 hills, with an average of approximately 350 ears for the five replications. At Isabela, where the corn was planted in drill rows, each plot consisted of a single row running the length of the field. Each plot averaged about 140 plants each and produced an average of over 500 ears per treatment in five replications.

Chemical controls consisted of insecticides applied in dust form early in the morning while the silks were moist with dew. All dusting was done by hand with a small plunger-type duster that directed the dust to the silks. In the experiment at Mayagüez, completed in February, dusting was begun near the mean silking date and continued until the silks had dried. Four applications of dust were made on December 27 and 30, 1935, and January 2 and 5, 1936. In an attempt to obtain a higher percentage of control in later experiments, applications of dust were begun as soon as a few silks appeared and continued until they dried. In the trials completed in June 1936 dusting was done as often as twice a week. Seven applications were made at Mayagüez beginning May 1 and ending May 27, and seven at Isabela beginning May 3 and ending May 24. The results are summarized in table 5.

An analysis of variance (table 6) of the three experiments gives evidence of some highly significant differences between the treatments. Differences required for significance are given in table 5. In all three trials barium fluosilicate showed a highly significant difference from the check. However, the percentages of control were not high enough to warrant its use. Derris showed significance from the check in two of the three experiments. Arsenates of magnesium and lead showed significance in only one out of three experiments, and their percentages of control were very poor. In spite of the significant reductions, none of the insecticidal materials tried gave sufficient control to be of value.

The mechanical and manual methods of control were all designed to prevent the young larvae from working down through the silks to the

TABLE 5. *Efficacy of dusts for the control of the corn earworm, Puerto Rico, 1936*

TREATMENT	TEST AT MAYAGÜEZ COMPLETED FEBRUARY 3			TEST AT MAYAGÜEZ COMPLETED JUNE 1			TEST AT ISABELA COMPLETED JUNE 5		
	EARS	EARS INFESTED	CONTROL	EARS	EARS INFESTED	CONTROL	EARS	EARS INFESTED	CONTROL
	Number	*Percent*	*Percent*	*Number*	*Percent*	*Percent*	*Number*	*Percent*	*Percent*
Barium fluosilicate and talc 1 : 1	161	11.8	57.6	361	36.3	34.6	542	30.2	35.6
Derris and talc 1 : 3	186	17.9	35.6	357	48.8	12.1	533	33.7	28.1
Magnesium arsenate and talc 1 : 4	193	22.6	18.7	339	47.2	15.0	546	33.7	28.1
Lead arsenate and talc 1 : 4	209	27.3	1.8	354	49.4	11.0	538	36.7	21.8
Check	223	27.8	—	321	55.5	—	552	46.9	—
Required significant difference for odds of 19 to 1		8.28			8.69			7.01	
Required significant difference for odds of 99 to 1		11.61			11.97			9.65	

TABLE 6. *Analysis of variance of chemical tests used against the corn earworm, Puerto Rico, 1936*

SOURCE OF VARIATION	LOCATION AND DATE OF EXPERIMENTS					
	MAYAGÜEZ FEBRUARY		MAYAGÜEZ JUNE		ISABELA JUNE	
	DEGREES OF FREEDOM	MEAN SQUARE	DEGREES OF FREEDOM	MEAN SQUARE	DEGREES OF FREEDOM	MEAN SQUARE
Blocks	3	42.51	4	22.42	4	14.25
Treatments	4	181.35*	4	244.56*	4	205.49*
Error	12	28.91	16	42.04	16	27.34

* Highly significant.

developing grain. The plots were examined twice weekly, and those ears that had silked were treated. This process was continued until the corn finished silking. The following methods were used: (1) A hog ring was clamped around the tip of the ear by the use of special pliers; (2) a piece of light-weight brown wrapping paper about 4 by 6 inches was wrapped around the tip of the ear and tied with a string to form a paper cap over the silks and ear tip; (3) a piece of No. 18 soft galvanized wire was placed around the ear tip and tightened with a pair of pliers;

TABLE 7. *Efficacy of mechanical and manual methods for the control of the corn earworm in Puerto Rico, 1936*

	TEST AT MAYAGUEZ COMPLETED FEBRUARY 3			TEST AT MAYAGUEZ COMPLETED JUNE 1			TEST AT ISABELA COMPLETED JUNE 5		
	EARS	INFESTED EARS	CONTROL	EARS	INFESTED EARS	CONTROL	EARS	INFESTED EARS	CONTROL
	Number	*Percent*	*Percent*	*Number*	*Percent*	*Percent*	*Number*	*Percent*	*Percent*
Hog rings	224	5.0	82.0	342	5.9	89.4	523	5.1	89.1
Paper caps	127	4.0	85.6	304	8.2	85.2	518	8.5	81.9
Wires	172	5.2	81.3	—	—	—	490	6.3	86.6
Strings	163	6.6	76.3	—	—	—	518	11.6	75.3
Cut silks	201	9.4	66.2	338	22.3	59.8	528	17.9	61.8
Squeezing the tips	198	14.2	48.9	336	27.2	51.0	514	23.0	51.0
Check	223	27.8	—	321	55.5	—	552	46.9	—
Required significant difference for odds of 19 to 1		7.26			6.48			3.43	
Required significant difference for odds of 99 to 1		9.95			8.92			4.65	

(4) a piece of string was tied around the ear in a similar manner; (5) the silks were cut off with a pair of scissors; and (6) the tips of the ears were squeezed by hand. Care was exercised in applying those methods that might interfere with pollination. In the application of hog rings, strings, and wires, room enough for the ear to develop was allowed. Results of the mechanical and manual methods are presented in table 7.

Analysis of the data by the variance method (table 8) shows that there are some highly significant differences among the treatments, and the amounts by which two treatments must differ to be significant are

shown in table 7. It will be noted that all the treatments showed highly significant differences from the check in all the experiments. Hog rings gave the best control in two out of three trials, with the wires, paper caps, and strings nearly as good. By the use of special pliers the hog rings could be applied more rapidly and easily than the other treatments, and under labor costs in Puerto Rico at about $15 for an acre of 8,000 ears. Cutting the silks, after pollination, showed a reduction of infestation over the check, but the tips of the ears thus exposed became ideally suited to oviposition by the fly *Euxesta stigmatias,* and as a result large numbers of ears so treated became maggot infested. The materials for the paper caps were cheap but the labor necessary in their application increased their cost. The applications of strings would cost approximately $9.47 per acre of 8,000 ears. With a good market price for sweet corn, the use of some of these methods would be feasible. It is possible that a lighter, cheaper ring could be substituted for the hog ring at a lower cost. All these methods of protection gave such encouraging results that they should be further investigated.

TABLE 8. *Analysis of variance of mechanical and manual methods used for the control of the corn earworm in Puerto Rico, 1936*

SOURCE OF VARIATION	LOCATION AND DATE OF EXPERIMENTS					
	MAYAGÜEZ FEBRUARY		MAYAGÜEZ JUNE		ISABELA JUNE	
	DEGREES OF FREEDOM	MEAN SQUARE	DEGREES OF FREEDOM	MEAN SQUARE	DEGREES OF FREEDOM	MEAN SQUARE
Blocks.....	3	25.33	4	10.13	4	16.08
Treatments.	6	286.39*	4	1,974.72*	6	1,077.23*
Error.....	18	23.90	16	23.37	24	6.90

* Highly significant.

SUMMARY

Investigations of the corn insects of Puerto Rico were made during the period extending from August 1935 to June 1936. Four species of insects were found of importance to the corn crop of the island, viz, the corn leafhopper, the otitid fly *Euxesta stigmatias,* the fall armyworm, and the corn earworm.

Three experiments were conducted with dusts against the fall armyworm. In these lead arsenate gave the best results, with control up to

88.2 percent. Barium fluosilicate was less satisfactory. Some improvement appeared to be gained from dusting at weekly rather than at 10-day intervals.

Chemical, mechanical, and manual methods were tried against the corn earworm. Of the chemicals, barium fluosilicate gave the best control, but burned the plants severely. Although some significant degrees of control were obtained, none of the insecticides gave encouraging results against the corn earworm. Mechanical and manual methods designed to prevent the larvae from working from the silks to the grain gave good results. The application of hog rings, paper caps, strings, and wires all gave substantial control. Because of the promising results obtained, these methods would appear to be worthy of further study.