The Journal of Agriculture of the University of Puerto Rico

In continuation of The Journal of the Department of Agriculture of Puerto Rico

Published by The Agricultural Experiment Station, Río Piedras, P. R.

Published Quarterly: January, April, July and October of each year.

VOL. XXIV APRIL 1940 No. 2

THE BEAN POD BORERS IN PUERTO RICO

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Introduction

On April 5, 1935, certain funds were made available for the study of insects in Puerto Rico, and part of the amount allotted was assigned to the study of three species of pod borers[1] which commonly attack the pods of wild and cultivated legumes. The work was planned to include investigations of control measures, life histories, populations, distribution, and host plants. Although the principal vegetable-producing area in Puerto Rico is located near San Juan, on the northeastern end of the Island, the presence of the Puerto Rico Agricultural Experiment Station[2] at the extreme western end offered many advantages there which would not have been available elsewhere, and much of the work was done there.

Dry beans for local consumption are produced in practically all parts of the Island, although very few are found in the extreme western end; and green beans are grown in the San Juan and Isabela vegetable-producing areas for local use and for shipment to the mainland. It was expected that lima beans would be found in rather large quantities, but because of losses resulting from pod borers and disease, and because of the restrictions on the export

1. *Maruca testulalis* (Gayer), *Etiella zinckenella* (Treitschke) (lima bean pod borer), and *Fundella cistipennis* (Dyar) (Caribbean pod borer).

2. The writer wishes to express his appreciation of the helpful spirit of cooperation shown by Atherton Lee, Director of the Station. Mr. Lee made it possible for Wallace Bailey, Associate Physiologist at the Station, to coordinate much of his work with that done by the author, thereby enabling the latter to conduct certain insecticide studies which he would otherwise have been unable to complete. Dr. Alfred Watson, Biometrician at the Station, aided greatly in analyzing the data from several experiments. The cooperation afforded by Luis A. Serrano, Agronomist in charge of the Insular Experiment Station at Isabela, is gratefully acknowledged. The writer also wishes to acknowledge the helpful attitude shown by Dr. George N. Wolcott, Entomologist at the Insular Experiment Station at Río Piedras.

of diseased and wormy pods, this type of bean has almost disappeared from the Island. There is reason to believe that lima beans might again become a profitable crop if a satisfactory control for pod borers could be found.

Reports of previous workers (1) (2) (3) indicate that *Maruca testulalis* is not ordinarily found in large numbers in Puerto Rico. For some unexplained reason this species was found far more numerous in cultivated legumes during most of the period of these investigations[3] than either *Etiella zinckenella* or *Fundella cistipennis*, and in some cases *M. testulalis* was almost entirely responsible for the total destruction of large fields of beans. Despite the fact that *M. testulalis*, which is not known to occur on the mainland, is not ordinarily a major pest in Puerto Rico, this species is of great importance to the growers, since its presence, even in small numbers, in beans intended for export to the mainland, has necessitated the placing of certain restrictions on the shipment of green beans.

Distribution and Seasonal Histories

The three species of pod borers were present in all parts of the Island, although they were much more numerous in the lowland near the coast, where beans are produced in large quantities, than in the mountainous sections of the interior, where host plants are comparatively scarce. *Maruca testulalis* was by far the most injurious of the three species during the period of these investigations. *Etiella zinckenella* may actually have been as numerous as *M. testulalis*, but the former was found largely in the pods of wild legumes, particularly those of *Crotalaria incana* L., which grow in practically every part of the Island. *Fundella cistipennis* was present in much smaller numbers than either of the other species, and its activities were confined largely to the pods and vines of the cowpea *Vigna unguiculata* (L.) Walp.

Etiella zinckenella was present in at least moderate numbers throughout the year, although it was much less numerous in the dry winter months than in the humid months of summer. *Fundella cistipennis*, the least numerous of the three species, was also present during the entire year, but it was found in greatly reduced numbers during the winter months when green beans were being

3. July 1935 to October 1936.

exported to the mainland. This species, which during most of the year prefers cowpeas to all other host plants, was attracted in small numbers during the winter months to lima beans, which had in former years been grown in moderately large quantities. *Maruca testulalis* was most abundant in October, when it was found in great numbers in all kinds of cultivated beans. The most severe infestations were found in the vicinity of Yauco, on the south shore, and at Isabela, in the northwest corner of the Island. The infestation diminished gradually during the latter part of October and very rapidly in November, and practically disappeared in December, particularly on the south shore of the Island where the winter rainfall is very light. On the north shore, however, where the winter precipitation is somewhat greater, occasional larvae of *M. testulalis* were found in the pods of string and lima beans. The infestation remainded very low through the first 5 months of the year, but in June it increased rapidly, reaching its maximum early in October.

Observations by the author indicated that *Etiella zinckenella* was present during the winter months in slightly greater numbers than *M. testulalis,* although previous investigators (1) have found that the former practically disappears early in January and that the infestation remains very low until late in the spring. *E. zinckenella* was more numerous than *M. testulalis* in wild legumes, particularly in *Crotalaria incana,* but it was found commonly in cultivated hosts also. At no time during the course of the investigations herein reported did *E. zinckenella* cause damage even approaching the total destruction of a crop of beans. *M. testulalis,* on the other hand, caused very serious damage in hundreds of large fields of beans in the vicinity of Yauco, on the south shore, and near Isabela, on the north shore, the loss being total in several fields.

The third species, *Fundella cistippennis,* was found less abundant than either of the other species. It was present, however, in small numbers during the winter months in beans intended for export, thereby necessitating the inspection on the farm of all beans presented for shipment to the mainland.

Host Plants

Of *Maruca testulalis* (Geyer)

Maruca testulalis is essentially a pest of cultivated legumes, although it was often found infesting the bay bean (*Canavalia maritima* (Aubl.) Thou.), a wild legume which grows luxuriantly on most of the beaches of Puerto Rico, producing very large and fibrous pods. The cowpea *Vigna unguiculata,* which grows both wild and under cultivation in Puerto Rico, was also infested by *M. testulalis;* but the infestation was never severe. Other wild hosts were occasionally attacked, but this species confined its activities largely to cultivated hosts.

Of *Etiella zinckenella* (Treitschke)

In contrast to *Maruca testulalis, Etiella zinckenella* is primarily a pest of wild hosts, although it was found in great numbers in all types of cultivated beans. It was present during the entire period of the investigation in the pods of *Crotalaria incana,* one of the commonest of several wild species of *Crotalaria* found on the Island, but the pods of *C. retusa* L. were not found infested by any of the pod borers. *E. zinckenella* was observed in lima beans, string beans, and the native red and white beans, but in these hosts it was usually much less numerous than *M. testulalis.*

Of *Fundella cistipennis* (Dyar)

The favorite host of *Fundella cistipennis* in Puerto Rico is undoubtedly the cowpea *Vigna unguiculata,* which grows both wild and cultivated in all coastal portions of the Island. Lima beans were attacked, particularly during the winter months, but the infestation in this host was never severe. The bay bean (*Canavalia maritima*) and the sword bean (*C. ensiformis* (L.) D.C.), the first a wild legume found on most of the beaches and the second an excellent leguminous soiling crop, were often moderately infested. The pods of *Cassia occidentalis* L., a wild shrub found in many pastures, were also attacked.

Suspected Hosts

Several other plants, because of their similarity to plants

known to be infested by one or more of the pod borers, were strongly suspected of being hosts of these insects. *Crotalaria retusa* is very similar to *C. incana*, the favorite host of *Etiella zinckenella*, and it seemed probable that this species would be found infesting the former plant; but examination of more than 10,000 pods of *C. retusa* failed to disclose the presence of any pod borers. Another *Crotalaria, C. stipularia* Desv., also was found to be free from infestation. The pods of the wild lima bean *Phaseolus lunatus* L. are very similar to those of the cultivated type, but the former were never found infested. Pods from several tree legumes were examined from time to time, but no infestation was found in them. Bolls and squares from wild cotton (*Gossypium hirsutum* L.) and the fruit of the maga tree (*Montezuma speciosissima* Sesse and Moç.) were examined at many points on the Island, but no pod borer infestation was noted.

Coccinia cordifolia Cogn., one of the plants brought to Puerto Rico in connection with the study of rotenone-bearing plants, bears small cucumber-like fruits, none of which was found to be infested. Pods from *Tephrosia vogelii* Hook f., another species introduced for study of its rotenone content, were found to be moderately infested by *Etiella zinckenella*.

Character of Damage Caused by Pod Borers

The pod borers, as their name denotes, have the habit of boring into the pods of various wild and cultivated plants. The name fails to suggest, however, that the borers commonly attack the blossoms of many leguminous plants and that the stems of some of these plants are also damaged. There is reason to believe that the damage to blossoms and very small pods causes greater losses than the more noticeable damage to large pods. The stems are not ordinarily attacked, although the insects, particularly *Fundella cistipennis*, often are found in large numbers in the stems of the cowpea *Vigna unguiculata*. The stems of other plants are attacked occasionally, but only when the insects become so numerous as to destroy all available pods.

The females deposit most of their eggs on or near the blossoms and blossom buds, thus assuring the newly hatched larvae

a source of food for several days. These young larvae feed first upon the blossoms, causing many of them to drop to the ground, and later they attack the small pods, many of which also drop. It was not uncommon to find 100 or more blossoms and very small pods on the ground under a single hill of pole lima beans. The majority of these blossoms and pods showed evidence of having been damaged by pod borers.

While the three species of pod borers cause essentially the same type of injury, it is interesting to note that the larvae of *Maruca testulalis* invariably keep exit holes open in the sides of pods which they infest, and through these holes they force the feces, or waste material, which would otherwise accumulate within the pod. These feces often collect conspicuously on the outside of infested pods, facilitating the detection of those that are wormy (fig. 1). The other species leave almost no outside evidence of

Fig. 1. Green bean showing typical exit hole of larva of *Maruca testulalis*.

their presence except that infested pods sometimes become flaccid and wrinkled and often have a watery appearance, making them the more readily detected.

When small pods are attacked the entire contents are usually consumed (fig. 2), whereas the larger pods of lima beans and cow-

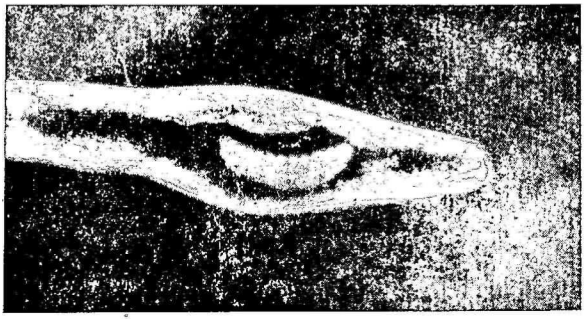

Fig. 2. Interior of bean pod containing *Maruca testulalis* larva.

peas may be only partially eaten. Regardless of the number of borers attacking a pod, however, the loss is usually total, since the infested pod becomes juicy and emits an unpleasant odor. The presence of a few infested pods in beans intended for local consumption is not particularly objectionable, since these beans usually reach the consumer before the infested pods have deteriorated sufficiently to spoil the others. A few infested pods in beans intended for export, however, may cause many uninfested beans to rot and may impart an objectionable odor to the entire shipment.

Field Experiments with Insecticides

The results of experiments conducted at Yauco and Isabela, the latter in cooperation with the Insular Experiment Station, showed conclusively that dusts containing 80 percent of natural cryolite or 80 percent of potassium fluoaluminate, applied twice to bush beans at the rate of 25 pounds per acre, were very effective in controlling the pod borers. The first application was made when many blossoms and small pods were present, and the second when most of the pods were full-grown but still green. The infestation in plats treated with either of these materials was reduced by more than 90 percent. Similar applications of pyrethrum dust containing 0.9 percent of pyrethrins were moderately effective, but the cost of the material was prohibitive. Two 25-pound-per-acre ap-

plications of derris dust containing 1 percent of rotenone were only slightly effective, whereas two 160-gallon applications of a spray containing sufficient derris powder to provide 0.025 percent of rotenone were moderately effective. Two applications, each at the rate of 25 pounds per acre, of a dust containing 80 percent of magnesium arsenate were approximately 50 percent effective.

The residue from the magnesium arsenate was too dangerous to humans or livestock to permit the use of this material on parts of the plants to be sent to market or used as feed. Since magnesium arsenate, to be effective against the pod borers, must be applied after the pods have formed, this material cannot be recommended as a control. The residues remaining on plants treated with the fluoaluminates are also objectionable, and until more information is available concering the effect of such residues upon man and livestock these materials should not be applied to plants after any part of the plant has formed that will be sent to market or consumed.

The incomplete results of an experiment conducted at Mayagüez in cooperation with the Federal Experiment Station provided no evidence that seven weekly applications of spray containing sufficient derris to provide 0.048 percent of rotenone would be more than slightly effective against the pod borers. The sprays were applied to pole lima beans at the rate of 500 gallons per acre. The addition of fish oil, alkylphenylbenzenesulfonic acid, or coconut-oil soap did not increase the effectiveness of the rotenone. A derris-nicotine sulfate spray containing 0.048 percent of rotenone, 0.09 percent of 40-percent nicotine sulfate, and 0.52 percent of 40-percent coconut-oil soap was no more effective against the eggs and larvae than a spray containing only the 0.048 percent of rotenone. Seven applications of a spray containing 0.23 percent of a commercially prepared aliphatic thyocyanate had no apparent effect on the eggs or larvae of the pod borers.

Varietal Tests

It has already been noted that the most common *Crotalaria* in Puerto Rico, *C. incana,* was almost invariably infested by larvae of the pod borers, the infestation often reaching 100 percent. *C.*

retusa, another common species, was at no time found infested, and reports of other workers (1) (2) indicate that this species is never attacked by pod borers. The reason for this is not entirely clear, since the pods of the two species are in many ways similar. The pods of *C. incana,* however, are somewhat smaller than those of *C. retusa* and much more hairy, whereas the pods of the latter are decidedly more brittle and crisp than the leathery pods of the former.

The decided preference of the borers for the hairy pods of *C. incana* suggested that the pods of certain types or varieties of lima beans might be more susceptible to pod borer attack than those of other types or varieties. The wild lima bean (*Phaseolus lunatus*) bears pods which closely resemble the crisp, papery pods of the small-seeded varieties of lima beans, and are somewhat similar to the crisp, hairless pods of *C. retusa,* which have never been found infested. Even when growing in close proximity to infested wild or cultivated plants the pods of the wild lima bean were invariably free from pod borer infestation.

The fact that certain wild legumes were immune or very resistant to pod borer attack suggested the possibility that certain varieties of lima beans might also be resistant, and with this in mind plantings of 17 varieties, each replicated four times, were placed immediately adjacent to a large planting of severely infested Pole Challenger lima beans. The 68 plats, each of which consisted of a 30-foot row, were arranged in four series, and each of the 17 varieties was represented once in each series.

The author left Puerto Rico before complete yield data could be obtained from the plats, but sufficient pods were harvested to indicate that the small-seeded varieties of lima beans were decidedly more resistant to pod borer attack than the large-seeded varieties, as shown in table 1.

TABLE 1

POD BORER INFESTATION IN SEVERAL VARIETIES OF LIMA BEANS. MAYAGUEZ, PUERTO RICO, 1936

Small-seeded varieties	Pods harvested	Pods infested		Large-seeded varieties	Pods harvested	Pods infested	
	Number	Number	Percent		Number	Number	Percent
Pole Varieties				*Pole Varieties*			
Carolina	557	5	0.90	King of the Garden	266	19	7.14
Florida Butter Speckled	625	13	2.08	Long Green Seeded	177	13	7.34
				Large Early Jersey	201	11	5.47
				Burpee's Giant Podded	258	13	5.04
				Sunnybrook	68	1	1.47
				Early Leviathan	243	16	6.58
				Burpee's Best	158	11	6.96
Bush Varieties				*Bush Varieties*			
Henderson's Dwarf	127	4	3.15				
Jackson's Wonder	145	2	1.38	Burpee's	21	0	0.00
Wood's Prolific	117	1	0.85	Fordhook	76	3	3.95
Burpee's Philadelphia	98	1	1.02	Improved	28	0	0.00
McCrea's	46	3	6.52				
Totals and averages	1,715	29	1.69	Totals and averages	1,496	87	5.82

It was unfortunate that time did not permit the taking of complete yield data from the several plats. The pole varieties produced pods several days earlier than the bush varieties, and it was therefore possible to harvest comparatively large numbers of pods from the former. The information obtained from observations of the small numbers of pods harvested was in no way conclusive, yet it did indicate that the small-seeded varieties were dicidedly more resistant to pod borer attack than the large-seeded varieties. The variety Carolina appeared to be particularly resistant, the 557 harvested pods being only 0.9 percent infested. Florida Butter Speckled, which is very similar to Carolina, also appeared to be at least moderately resistant. The small-seeded bush varieties appeared to be moderately resistant, but since these varieties produced marketable pods several days later than the small-seeded pole varieties, it was impossible to obtain sufficient mature pods to provide more than indicative information. With the exception of the variety Sunnybrook, which produced only 68 mature pods, all the large-seeded pole varieties appeared to be less resistant to attack than the small-seeded pole varieties. The large-seeded bush varieties had not produced sufficient pods upon which to base even indicative conclusions. It is known, however, that all the common large-seeded bush varieties are very susceptible to pod borer attack in Puerto Rico.

Summary

Three species of pod borers, *Maruca testulalis* (Geyer), *Etiella zinckenella* (Treitschke), and *Fundella cistipennis* (Dyar), were found commonly in 1935-36 infesting wild and cultivated leguminous plants in all parts of Puerto Rico. *E. zinckenella* and *M. testulalis* were about equally numerous, but the latter, because it confined its attacks almost entirely to cultivated plants, was by far the most important economically of the two. *F. cistipennis* was the least abundant of the three species, and although it was found largely in cultivated plants, it was much less destructive than either of the other species.

In addition to various legume crops the insects attacked several wild legumes, particularly *Crotalaria incana* L., one of the Island's commonest *Crotalarias*, and *Canavalia maritima* (Aubl.) Thou.,

commonly called the bay been. Some wild legumes, such as the wild lima bean (*Phaseolus lunatus* L.), and one of the commonest *Crotalarias,* (*C. retusa* L.), appeared to be highly resistant, if not inmune, to attack.

The pod borers deposit their eggs on or near the blossoms and blossom buds, thereby assuring ample food for the newly hatched larvae. Most of the injured blossoms drop to the ground, and it is not uncommon to find hundreds of them on the ground under bean plants.

Experiments conducted at Yauco, Isabela, and Mayagüez indicated that the pod borers could be successfully controlled by two 25-pound-per-acre applications of dust containing 80 percent of natural cryolite. Similar applications of pyrethrum dust were moderately effective, but the cost of the material was prohibitive. Dusts and sprays containing rotenone failed to provide satisfactory control.

Observation of various varieties and types of lime beans indicated that the small-seeded lima bean, particularly the variety Carolina, was highly resistant to pod borer attack.

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