Control of Downy Mildew of Lima Beans on Long Island

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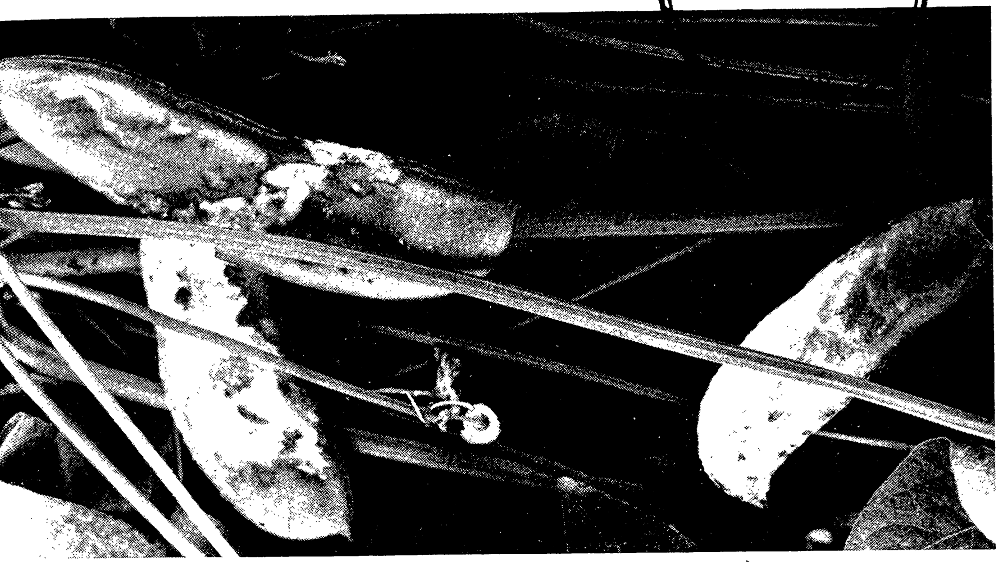

Lima Bean Pods Showing the Characteristic White Felt-like Growth Due to Downy Mildew.

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ABSTRACT

EXPERIMENTS on the control of downy mildew, *Phytophthora phaseoli*, on lima beans were conducted on Long Island during 1940 to 1945, inclusive. All fungicides were applied on a regular schedule at weekly intervals.

Downy mildew is primarily a pod destroyer, altho it does attack the foliage where it ordinarily causes little injury. The pods are attacked in all stages of growth, and in seasons favorable to the disease, losses may be heavy.

Spraying or dusting the plants with copper fungicides will control the disease. There was practically no difference in the efficiency of any of the copper fungicides used in these experiments for the control of mildew.

Copper fungicides did not noticeably discolor the pods, but copper injury in the form of rusty-brown spots does occur in transit if the beans are picked and packed when wet.

The organic fungicides used in these experiments failed to give commercial control of mildew with the exception of Dithane (D–14). With zinc sulfate and hydrated lime added, this material, in one test, was as effective as applications of copper.

Applications of any of the fungicides used did not affect either the set of beans or the yield in the absence of mildew.

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CONTROL OF DOWNY MILDEW OF LIMA BEANS ON LONG ISLAND

H. S. CUNNINGHAM

INTRODUCTION

The lima bean is an important crop on Long Island, with commercial plantings confined almost exclusively to the eastern part of Suffolk County where about 3,000 acres are grown annually. It is estimated that in 1946 the monetary value of the crop was around $600,000. Forkhook is the only variety grown and the crop is marketed almost entirely as green beans. The planting season extends from late April to mid-July, and harvesting usually commences early in August and extends into October, or until frost kills the plants. Plantings prior to July 1 are made on land reserved for that purpose, but the bulk of the acreage planted after that date follows a crop of early potatoes or possibly peas.

Lima beans grown on Long Island are subject to all of the common diseases affecting this crop on the eastern seaboard. Of these diseases downy mildew, caused by *Phytophthora phaseoli* Thaxt., is by far the most destructive and most feared by the growers. Like many other diseases affecting farm crops, downy mildew is dependent upon certain weather conditions for its development. The disease rarely appears on Long Island before the latter part of July, although in 1942 it was found as early as July 9. At this season of the year temperatures are high, localized thunder showers may occur, and on low-lying land near the ocean heavy fogs may develop, particularly at night. At the existing temperature, if the soil and plants remain wet for any length of time, infection is likely to occur and the disease will spread rapidly thru the fields. Rarely a season passes that some localized infection cannot be found and if precipitation is continued and widespread the disease becomes epidemic.

Downy mildew is primarily a pod destroyer. The pods are attacked in all stages of growth from flower to maturity. Young pods when attacked fail to develop further and simply shrivel up, while older diseased pods show the thick, white, felt-like growth which characterizes this disease. (See cover page illustration.) Once the disease becomes general in a field and conditions are favorable for infection, the pods are attacked as soon as they appear. Downy mildew also attacks the tips of flower and leaf shoots and petioles of younger leaves. The leaf blade may be attacked but is seldom seriously injured. The fact that the leaves are not usually affected may be misleading to the causal observer for a field of lima beans which may look healthy and vigorous may have virtually all of the pods badly affected with the disease (Fig. 1).

FIG. 1.—LIMA BEAN FIELD SHOWING APPARENTLY VIGOROUS AND HEALTHY PLANTS.
A very large proportion of the pods in this field were affected with downy mildew. Photographed August 20, 1942.

It has long been known that spraying lima bean plants with bordeaux mixture will control downy mildew to a large extent, and this practice has been quite generally followed by Long Island growers. Clayton[1] has stated that spraying with bordeaux mixture did not noticeably discolor the pods. This is true so far as visible discoloration is concerned and no ill effect from the bordeaux will become apparent provided the beans are picked and packed when dry. Beans packed while damp, however, are likely to develop rusty-brown spots by the time they have reached market (Fig. 2). These spots develop where

[1]Clayton, E. E. Spraying experiments with bush lima beans. *New York State Agr. Exp. Sta. Bul. No. 558. 1928.*

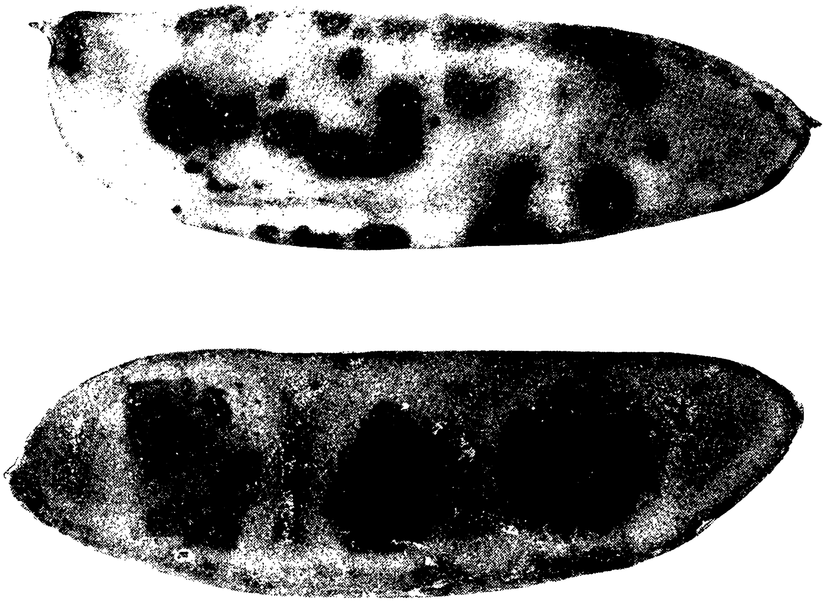

FIG. 2.—SPOTTING OF LIMA BEAN PODS DUE TO THE PRESENCE OF COPPER. The pods were picked when damp and packed in a container overnight.

the pods contact each other in the package. In recent years some growers have installed mechanical graders. Beans picked in the afternoon are placed in bags, the bags brought to the grading shed, and piled in a heap to be graded the next morning in preparation for shipment about noon. Under certain conditions these beans sweat during the night and by morning the loss from spotted pods may be heavy. It has been proved beyond question that this rusty-brown spotting is due to the presence of copper on the pods and that the insoluble coppers are equally as bad in this respect as is bordeaux mixture.

MATERIALS AND METHODS

All experiments were conducted on Fordhook since this is the only variety grown commercially on Long Island. The experiments carried on at the Long Island Vegetable Research Farm consisted, in the main, of 25-foot plots, randomized and replicated, with a guard row between each plot row. On outlying farms the size of the plot and number of replications necessarily varied with the size and character of the field available for the work. In general, all applications of fungicides were made on a regular schedule, at weekly intervals, in so far as weather conditions would permit.

The bordeaux mixture was made from stock solutions of lime and copper sulfate. The required amount of water was first put in the sprayer and the copper sulfate and lime slowly added with the agitator running. The insoluble coppers and organic materials were washed thru the screen by means of the overflow. A very satisfactory suspension was obtained by this method.

The sprays were applied with a power sprayer, using 300 pounds pressure and three nozzles per row. Applications were at the rate of 100 gallons per acre. By this means good coverage was obtained on all parts of the plants. The power sprayer was an ordinary orchard model made over to suit the job. The large tank and skids were discarded and the engine and pump mounted on a wooden frame which could be easily loaded on a pick-up truck by means of a chain hoist (Fig. 3).

FIG. 3.—SPRAYING LIMA BEAN PLOTS WITH A MODIFIED ORCHARD SPRAYER MOUNTED ON A PICK-UP TRUCK.

The unit was mounted so that the agitator shaft was on one side, and by using a longer chain, could be connected with a 20-gallon wooden tank placed on an extension of the wooden frame. The tank was held in place by means of two uprights secured with hooks. A loose-fitting cover, containing an opening for a removable screen and also openings for the suction and overflow hoses, was placed on the tank. By lifting out the suction and overflow hoses, removing the top, and releasing the hooks, the tank could be emptied and cleaned in a matter of seconds. For small plot work where only small quantities of material were needed, this arrangement proved very satisfactory.

With such an outfit mounted on a pick-up truck it was not possible to drive thru the fields without injuring the plants. This necessitated driving along the side of the area to be sprayed and using a long hose to which the boom was attached. One man drove the pick-up, while another man handled the boom. At first an additional man was used to support the length of hose but later a removable arm was constructed out of pipe which projected from the side of the pick-up and to which the hose was attached. With this arrangement one man, in addition to the driver, could spray the randomized plots with ease within a limit of 12 rows (Fig. 3). Plantings at the Research Farm were laid out with roadways on either side of the area to be sprayed. In working on outlying farms it was necessary to select fields, or portions of fields, where it was possible to drive along the side.

The first year dusting was done with a hand duster. The following year a wheelbarrow type of power duster was purchased and this was used thereafter in all dusting operations. This duster was equipped with underneath nozzles which gave good coverage and was particularly effective if there was any wind. Dusts were applied at the rate of 30 pounds per acre.

Experiments carried out on outlying farms were not too satisfactory. Altho every effort was made to lay out plots in fields where mildew might be expected to appear, we failed to get any noticeable infection even in an epidemic year like 1942. Artificial inoculation was, of course, out of the question in these commercial plantings. At the Research Farm all plots were inoculated whenever it was possible to gather infected pods. A spore suspension was made by scrubbing the infected pods with a brush and diluting to give sufficient suspension to inoculate all plots. The inoculum was then applied with a watering can when the plants were wet. In this way uniform infection was obtained thruout the field.

Data on the efficiency of fungicides were taken by counting the pods, except in a few instances where either time or labor precluded making counts. The weight of marketable pods was also recorded. In those years when mildew was present the infected pods were counted, but no attempt was made to differentiate between degree of infection. All infected pods were considered as unmarketable and the yield in ounces as given in the tables refers only to beans of marketable size, free from mildew.

Repeated efforts were made to secure a uniform stand in these plots by heavy seeding and subsequent thinning, but in the end this was not found to be practical. Due to insect injury, bacterial blight, or mechanical injury during cultivation, there was a wide variation in the number of plants in these plots at harvest time. For this reason the data given in the tables are on the basis of 100 plants.

With the exception of those plots treated with the combination dust containing sulfur and rotenone, all plots were dusted at intervals for control of the Mexican bean beetle and red spider mite as soon as these insects appeared.

EXPERIMENTAL RESULTS

In 1940, two plantings of lima beans were made at the Research Farm, one on May 9, the other on June 3. Spraying and dusting operations were started on the first planting on July 10 and on the second planting on July 19. Both plantings received six applications at approximately weekly intervals. In both cases the plants were inoculated with a spore suspension of *Phytophthora phaseoli* on July 20.

Thruout these experiments bordeaux mixture 8–8–100 caused some injury to the plants. This injury took the form of a bronzing, thickening, and inward curling of the leaf blade. Injury of this type is much more marked with bordeaux mixture 8–4–100, and because of this it was not used after the first season. Bordeaux mixture 8–4–100 is commonly used on potatoes, but the lima bean is apparently more susceptible to copper injury. That the injury to the foliage is due to copper is indicated by the fact that it is more severe when the lime content in the bordeaux mixture is reduced. In small plot tests where the lime content in the bordeaux mixture was increased to 6 pounds per 100 gallons, there was no reduction, or change in this type of injury. Neither did a reduction in both copper and lime in a 6–6–100 formula reduce the injury below that of the 8–8–100 except with very young plants. The data given in the tables show, however, that this injury to the foliage does not affect the total number of pods produced, nor the weight of marketable pods, under Long Island conditions.

In the planting made on May 9 the total number of pods produced was significantly higher on those plots treated with a combination dust containing copper, sulfur, and derris than with any of the other treatments used. All sprays and dusts used gave good commercial control of mildew as evidenced by the number of clean pods and yield (Table 1). The data are significant as compared with the untreated check both as to the number of clean pods and yield, but there is no significant difference between treatments as measured by the number of clean pods. The yield was significantly higher with the combination dusts than with bordeaux mixture.

In the second planting made on June 3 the various fungicides were much more efficient than in the first planting. The difference is probably due to starting spraying and dusting operations when the plants were smaller and the plants becoming infected at an earlier stage in their growth. The total number of pods produced, number of clean pods, and yield were significantly higher with all treatments as compared with the untreated check. In comparison with bordeaux mixture the combination dusts were again more efficient.

Mildew failed to appear in the experiments on outside farms in

TABLE 1.—EFFICIENCY OF VARIOUS FUNGICIDES FOR THE CONTROL OF DOWNY MILDEW ON LIMA BEANS IN 1940, WITH DATA BASED ON 100 PLANTS.

FUNGICIDE	FORMULA	RESEARCH FARM*						FARM No. 1 PLANTED MAY 15, YIELD, OUNCES†	FARM No. 2 PLANTED JUNE 7, YIELD, OUNCES‡	FARM No. 3 PLANTED MAY 30§	
		Planted May 9			Planted June 3					Total yield	
		Total pods	Clean pods	Yield, ounces	Total pods	Clean pods	Yield, ounces			Pods	Ounces
Untreated											
		1,229	873	159	1,190	463	107	360	511	721	237
Sprays											
Bordeaux mixture	8–8–100	1,358	1,296	321	1,534	1,496	417	309	617	1,260	296
Bordeaux mixture	8–4–100	1,349	1,299	342	1,562	1,514	388	271	549	1,141	435
Yellow Cuprocide	1½–100	1,172	1,118	267	1,642	1,553	393	310	588	807	218
Cupro-K	4–100	1,461	1,323	321	1,742	1,558	437	358	700	1,035	339
Dusts											
Yellow Cuprocide-sulfur-derris	4–30–15	1,496	1,413	402	2,038	1,950	515	321	662	1,268	341
Cupro-k-sulfur-derris	12–30–15	1,596	1,474	430	2,075	1,925	545	301	811	1,233	394
Copper lime	20–80	1,380	1,317	338	1,757	1,674	473	277	640	1,090	348
L.S.D. (19:1)		265	234	64	222	196	61	69	176	300	243

*Replicated 8 times; 6 applications.
†Replicated 12 times; 5 applications.
‡Replicated 8 times; 6 applications.
§Replicated 8 times; 5 applications.

1940. Only yield data were taken on farms Nos. 1 and 2. On farm No. 1 all treated plots gave a lower yield than the untreated check but only in the case of bordeaux mixture 8–4–100 and copper lime dust are the figures significant (Table 1). On farms Nos. 2 and 3 the yield data on the treated plots, with one exception, are slightly higher than on the check, but only the Cupro-K combination dust on farm No. 2 gave a significantly higher yield. On farm No. 3 the total number of pods produced was increased by all treatments and, with the single exception of the Yellow Cuprocide spray, the figures are significant (Table 1).

In 1941, two plantings were made at the Research Farm and two experiments were carried on with growers. With one of the latter both spray and dust were used, while the other was a straight dusting experiment. No mildew appeared in any of these plantings nor was any available for inoculation of the plots at the Research Farm. Applications of fungicides were made at weekly intervals.

In the experiment planted on May 8 there was no significant difference in total number of pods produced on treated plots as compared with the untreated check, but there was a difference between treatments. The plot treated with Yellow Cuprocide spray showed heavier pod production than where Spergon spray or any of the dusts were used, and the figures were significant (Table 2). In this respect the copper oxychloride sulfate plot, altho not better than the bordeaux mixture plot, was better than the Spergon spray plot or any of the dust plots except copper lime. As far as yield is concerned the insoluble coppers used as sprays were the only fungicides significantly better than the check, and they were also better than Spergon applied either as a spray or dust. The yield from copper oxychloride sulfate treated plots was significantly higher than bordeaux mixture, and this was the only instance in which this occurred thruout the progress of this work.

The planting made on June 10 presents a somewhat different picture. In this experiment plots treated with Yellow Cuprocide combination dust produced more pods than either the untreated check or any of the sprays except copper oxychloride sulfate. The same is true of yield (Table 2).

On the outside farms there was no difference in total pod production on the treated plots. On farm No. 4 the plots receiving Yellow Cuprocide spray, copper oxychloride sulfate, and copper lime dust showed yields significantly below that of the untreated check.

TABLE 2.—EFFECT OF VARIOUS FUNGICIDES ON LIMA BEANS IN THE ABSENCE OF DOWNY MILDEW IN 1941, WITH DATA BASED ON 100 PLANTS.

FUNGICIDE	FORMULA	RESEARCH FARM*				FARM NO. 4 PLANTED APRIL 30*		FARM NO. 5 PLANTED JUNE 5†	
		Planted May 8		Planted June 10					
		Total pods	Yield, ounces	Total pods	Yield, ounces	Total pods	Yield, ounces	Total pods	Yields, ounces
Untreated									
		1,451	349	1,297	346	1,348	392	1,496	349
Sprays									
Bordeaux mixture	8–8–100	1,464	360	1,286	340	1,313	372	—	—
Yellow Cuprocide	1½–100	1,613	412	1,278	309	1,155	344	—	—
Copper oxychloride sulfate	4–100	1,568	437	1,419	361	1,345	354	—	—
Tri-basic copper sulfate	4–100	1,523	415	1,258	335	1,377	384	—	—
Spergon	2–100	1,267	310	1,328	346	1,304	376	—	—
Dusts									
Yellow Cuprocide-sulfur derris	4–30–15	1,205	361	1,630	404	1,379	378	1,558	420
Tri-basic copper sulfate	12–100	1,253	343	1,455	397	1,345	385	—	—
Copper lime	20–80	1,348	347	1,491	387	1,185	340	1,697	409
Spergon	6–100	1,267	310	1,346	370	1,433	389	—	—
L.S.D. (19:1)		254	69	225	50	303	33	276	63

*Replicated 4 times; 5 applications.
†Replicated 3 times; 5 applications.

Mildew was found as early as July 9 in 1942 and by early August was epidemic. The two plantings made at the Research Farm, one on May 5 and the other on June 12, were inoculated on July 22. No untreated check was included in the plan for the experiment planted on May 5.

There was no significant difference in the first planting in total pod production due to sprays, nor with Spergon and Fermate used as dust. On plots treated with copper lime dust pod production was heavier than with any of the sprays except copper oxychloride sulfate and Spergon, and also heavier than with dusts containing organics (Table 3). All copper sprays and dusts were equally efficient in mildew control as measured by the number of clean pods and yield. In these respects both Spergon and Fermate failed to give as good control as the coppers.

In the experiment planted on June 12, total pod production was not affected by treatment, except with Cupro-K spray and Yellow Cuprocide dust (5 per cent) where, in both cases, the total number of pods was increased. Spraying with bordeaux mixture, copper oxychloride sulfate, and Cupro-K, together with all copper dusts, significantly increased the number of clean pods as compared with no treatment, but there was no significant difference between these treatments (Table 3). Yellow Cuprocide, together with Spergon and Fermate, either as spray or dust, failed to give measurable control of mildew. The addition of zinc sulfate and lime to the Fermate did not increase its efficiency for mildew control. Altho Yellow Cuprocide and Fermate spray, as well as Spergon dust, significantly increased the yield over the untreated check there was no significant difference between these fungicides.

Very little mildew appeared in the section of the field on which the experiment was conducted on farm No. 6, altho the disease was prevalent in other parts of the field. There are no significant differences in the yield records from this farm.

In 1943, as in former years, two experiments were carried on at the Research Farm and two additional ones on outlying farms. Mildew was virtually nonexistent in commercial plantings thruout the season. Early in August a few diseased pods were found in one field. The plots at the Research Farm were inoculated, but weather conditions were such that no infection occurred.

The data given in Table 4, for the planting made on May 11, show that the total pod production was not affected by applications of fungi-

TABLE 3.—EFFICIENCY OF VARIOUS FUNGICIDES FOR THE CONTROL OF DOWNY MILDEW ON LIMA BEANS IN 1942, WITH DATA BASED ON 100 PLANTS.

FUNGICIDE	FORMULA	RESEARCH FARM*						FARM NO. 6 PLANTED JUNE 6*		
		Planted May 5			Planted June 12					
		Total pods	Clean pods	Yield, ounces	Total pods	Clean pods	Yield, ounces	Total pods	Clean pods	Yield, ounces
Untreated										
		—	—	—	1,154	224	29	655	642	223
Sprays										
Bordeaux mixture	8-8-100	1,122	881	295	1,182	826	183	—	—	—
Yellow Cuprocide	1½-100	1,185	748	294	1,092	320	70	—	—	—
Copper oxychloride sulfate	4-100	1,323	827	295	1,308	682	155	—	—	—
Cupro-K	4-100	—	—	—	1,521	569	142	—	—	—
Spergon	2-100	1,311	527	190	1,075	278	50	—	—	—
Fermate	1-100	1,175	519	197	1,243	266	72	—	—	—
Fermate-zinc sulfate-hydrated lime	1-½-1-100	—	—	—	1,223	249	61	—	—	—
Dusts										
Yellow Cuprocide	3-100	1,521	809	299	1,250	423	101	569	540	189
Yellow Cuprocide	4-100	—	—	—	1,387	543	112	—	—	—
Yellow Cuprocide	5-100	—	—	—	1,433	480	128	—	—	—
Red Cuprocide	6-100	1,408	876	306	1,278	409	99	565	561	206
Copper lime	20-80	1,592	808	271	1,259	543	100	587	567	205
Spergon	3-100	1,187	459	161	1,205	347	72	—	—	—
Fermate	3-100	1,228	361	127	1,124	203	47	—	—	—
L.S.D. (19:1)		298	141	50	243	171	38	106	196	41

*Replicated 4 times; 6 applications.

TABLE 4.—EFFECT OF VARIOUS FUNGICIDES ON LIMA BEANS IN THE ABSENCE OF DOWNY MILDEW IN 1943, WITH DATA BASED ON 100 PLANTS.

Fungicide	Formula	Research Farm* Planted May 11 Total pods	Research Farm* Planted May 11 Yield, ounces	Research Farm* Planted June 11 Total pods	Research Farm* Planted June 11 Yield, ounces	Farm No. 7 planted July 7† Total pods	Farm No. 7 planted July 7† Yield, ounces	Farm No. 8 planted July 7† Total pods	Farm No. 8 planted July 7† Yields, ounces
Untreated									
		1,013	330	928	234	1,162	392	1,625	553
Sprays									
Bordeaux mixture	8–8–100	916	314	952	217	1,502	479	1,410	434
Yellow Cuprocide	1½–100	1,009	343	967	225	1,167	401	1,306	356
Copper oxychloride sulfate	4–100	1,051	357	960	222	1,310	443	1,517	428
Dithane (H. E. 175)	2–100	946	318	962	240	1,222	385	1,572	523
Fermate	1½–100	978	351	968	243	1,540	436	1,520	450
Dusts									
Yellow Cuprocide	4–100	1,119	392	953	224	1,315	449	1,347	449
Copper lime	20–80	1,034	367	982	251	1,376	466	1,671	530
L.S.D. (19:1)		122	47	165	60	365	116	311	95

*Replicated 8 times; 5 applications.
†Replicated 5 times; 5 applications.

cides as compared with no treatment, but both copper oxychloride sulfate and Yellow Cuprocide plots were significantly better than the bordeaux mixture plots in this respect. No increase yields were noted in the spray plots. In the Yellow Cuprocide dust plot an increase was noted. Higher yields were recorded in both the Yellow Cuprocide and copper lime dust plots than were present in the bordeaux mixture plot.

In the planting made on June 11 there was no significant difference in either total pods or yield due to treatment, nor was there any difference between treatments.

On farm No. 7 Fermate was the only fungicide used which showed an increased total pod production over the untreated check. The plot receiving Yellow Cuprocide spray produced fewer pods than any of the treated plots but was not significantly lower than any of the others except Fermate. Yield differences were not significant.

Yellow Cuprocide spray plots on farm No. 8 again made the poorest showing of all treatments used. It was significantly lower in total pod production than either the check or copper lime dust plots. Copper lime dust was better in this respect than Yellow Cuprocide, either as spray or dust. Plots treated with Dithane (H.E. 175) and copper lime dust were the only ones which showed increased yields over the check, but there was no difference between these two treatments.

The work during the 1944 season was confined entirely to the Research Farm. The experiment was planned with the idea of obtaining information relative to the value of the addition of zinc sulfate and hydrated lime to sprays containing insoluble copper or organic materials. Because of lack of space it was not possible to include dusts in this layout, but a straight dusting experiment was carried on separately.

The 1944 season was very dry. Extensive scouting failed to locate any downy mildew, nor was it reported from any section of Long Island during the season.

In the absence of mildew the addition of zinc sulfate and hydrated lime to any of the fungicides did not significantly affect the total number of pods produced, nor the yield, in either of the two plantings (Table 5).

Of the 14 treatments used in the planting made on May 13, 6 showed a higher pod production than the untreated check, 7 were higher than bordeaux mixture, and 3 higher than copper oxychloride sulfate. The bordeaux mixture plot gave the lowest yield, and was the only plot significantly different from the check. Nine of the treated

TABLE 5.—EFFECT OF VARIOUS FUNGICIDES ON LIMA BEANS IN THE ABSENCE OF DOWNY MILDEW IN 1944, WITH DATA BASED ON 100 PLANTS.

FUNGICIDE	FORMULA	RESEARCH FARM					
		Planted May 13*		Planted June 15†		Planted June 15*	
		Total pods	Yield, ounces	Total pods	Yield, ounces	Total pods	Yield, ounces
		Untreated					
		670	126	604	144	757	172
		Sprays					
Bordeaux mixture	8–8–100	639	107	558	133	—	—
Copper oxychloride sulfate	4–100	676	111	599	137	—	—
Copper oxychloride sulfate‡	4–100	—	—	579	136	—	—
Tri-basic copper sulfate (Tenn)	4–100	770	124	578	133	—	—
Tri-basic copper sulfate (Tenn)‡	4–100	742	123	600	137	—	—
Tri-basic copper sulfate (PD)	4–100	716	116	608	139	—	—
Tri-basic copper sulfate (PD)‡	4–100	769	129	587	139	—	—
Compound A	4–100	710	115	606	138	—	—
Compound A‡	4–100	769	128	611	141	—	—
Dithane (H.E. 175)	2–100	758	126	599	142	—	—
Dithane (H. E. 175)‡	2–100	779	136	615	144	—	—
Fermate	1½–100	724	128	638	146	—	—
Fermate‡	1½–100	690	127	635	148	—	—
U.S.R. (604)	1½–100	756	130	592	138	—	—
U.S.R. (604)‡	1½–100	697	122	613	143	—	—
		Dusts					
Yellow Cuprocide	4–100	—	—	—	—	645	158
Copper lime	10–80	—	—	—	—	724	178
Tri-basic copper sulfate (Tenn)	12–100	—	—	—	—	717	178
Copper oxychloride sulfate	12–100	—	—	—	—	707	172
Compound A	12–100	—	—	—	—	724	174
Dithane (H. E. 175)	4–100	—	—	—	—	667	169
L.S.D. (19:1)		82	15	75	22	127	31

*Replicated 8 times; 5 applications.
†Replicated 15 times; 5 applications.
‡Zinc sulfate (½ pound) and hydrated lime (1 pound) added.

plots yielded higher than bordeaux mixture and six higher than copper oxychloride sulfate.

There was no significant difference due to treatment, in either pod production or yield, in the spray and dust experiments planted on June 15 when compared with the untreated check. In pod production alone, two of the sprays were significantly better than bordeaux mixture.

Again, in 1945, the work was confined to the Research Farm, and only one planting was made on June 12 (Table 6). The first application of fungicides was made on July 23 and the last on September 5. The plants were inoculated on August 6 and the fungus remained active thruout the season.

In this experiment Dithane (D–14), when used alone, was the only treatment not significantly better than the check in total pod production. There was no difference in this respect between the other treatments. From the standpoint of clean pods all of the fungicides used were efficient in controlling mildew with the exception of Fermate spray. Dithane (D–14), when used alone, was inferior to the copper

TABLE 6.—EFFICIENCY OF VARIOUS FUNGICIDES FOR THE CONTROL OF DOWNY MILDEW ON LIMA BEANS IN 1945, WITH DATA BASED ON 100 PLANTS.

FUNGICIDE	FORMULA	RESEARCH FARM PLANTED JUNE 12*		
		Total pods	Clean pods	Yield, ounces
Untreated				
		923	444	126
Sprays				
Bordeaux mixture	8–8–100	1,117	948	315
Copper oxychloride sulfate	4–100	1,183	994	321
Tri-basic copper sulfate	4–100	1,165	949	301
Dithane (D-14)	2 qts.–100	988	666	216
Dithane (D-14)-zinc sulfate-hydrated lime	2 qts.–100	1,153	843	295
Fermate	1½–100	1,148	580	185
Dusts				
Yellow Cuprocide	4–100	1,278	777	219
Tri-basic copper sulfate	12–100	1,092	835	300
Copper lime	20–80	1,131	848	259
L.S.D. (19:1)	20–80	174	175	48

*Replicated 8 times; 5 applications.

sprays, but the addition of zinc sulfate and hydrated lime to this material increased its value to the point where it was as efficient as the coppers. Yields from all treatments were significantly higher than the check. Dithane (D–14) used without zinc sulfate and lime, Fermate, and Yellow Cuprocide dust proved to be inferior to the other treatments.

DISCUSSION AND SUMMARY

Downy mildew of lima beans, caused by *Phytophthora phaseoli,* is a serious disease of this crop on Long Island in some seasons. During the six years the work reported here was in progress, downy mildew was not a factor in lima bean production except in 1940, 1942, and 1945, and only in 1942 was it epidemic. Even in 1942 no data of value on mildew control were obtained with experiments carried on away from the Research Farm. It was only at the Research Farm, where plots were uniformly inoculated, that data of value on the efficiency of fungicides were obtained.

Growers have sometimes questioned the advisability of applying fungicides to lima beans when the plants are in bloom. Thruout these experiments a regular schedule was followed for both spraying and dusting, provided weather conditions were favorable, and no attention was paid to bloom. While there are slight differences in the data, there is nothing consistent and it may be stated that total pod production was not affected to any extent by the application of fungicides either in the presence or absence of mildew. The tendency was towards heavier pod production where fungicides were applied. Since all of these experiments were either sprayed or dusted at least once during the height of the blooming period, there would seem to be no object in delaying applications because the plants are in bloom. The data indicates that none of the fungicides used were toxic enough to effect yields. In those years when mildew was absent the affect of applications of fungicides on yield was much the same as that for pod production.

Data on the efficiency of fungicides for mildew control are given in the tables as yield in ounces of marketable pods and number of clean pods. The yield data in themselves are probably not too reliable, but are rather an indication of the trend. Too frequently lack of sufficient labor, weather conditions, and other factors resulted in a considerable lapse of time before all plots could be harvested. This would inevitably result in differences in weight due to ripening of pods. Lima beans, once they have reached the marketable stage, mature rapidly under Long Island conditions, and lose weight in the process. The number of clean pods is a better criterion of the efficiency of the fungicides than is yield.

On the basis of clean pods there was very little difference in the efficiency of any of the copper sprays or dusts used in these experiments so far as control of mildew was concerned. Good commercial control of mildew may be achieved with any of these fungicides if applied at weekly intervals. To be effective copper lime dust should be applied when the plants are wet. Dusts containing insoluble copper may be applied to dry plants, but even with these it is probably advisable to make applications when the plants are wet.

Bordeaux mixture will cause some injury to foliage, but on Long Island this does not seem to affect the yield. No noticeable foliage injury developed from the use of insoluble coppers.

The organic materials used were of little value in controlling downy mildew. The single exception was Dithane (D–14) used with the addition of zinc sulfate and hydrated lime in 1945. In one year's test the combination proved to be as efficient as the copper fungicides. The 1945 season, during which this latter material was tested, was not particularly favorable for mildew, but it was the only year in which mildew was present in any of the experiments after Dithane in this form was available.