RELATION OF THE POTATO FLEA BEETLE TO COMMON SCAB INFECTION OF POTATOES [1]

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INTRODUCTION

Worm-track injury on potato tubers caused by the larvae of the potato flea beetle (*Epitrix cucumeris* Harr.) (*5*)[3] continues to be a serious problem to potato growers in the Greeley area of Colorado. Considerable damage is done to the foliage of the potato plant by the feeding of the adult beetles, but the damage to the tubers caused by the feeding of the larvae is of much more serious consequence. The infection of the worm tracks by common scab (*Actinomyces scabies* (Thax.) Güssow) is the most important phase of the tuber injury. Since the mechanics of this infection appears not to have been described, it is the purpose of this paper to show how the flea-beetle larvae may aid in scab infection of the potato tuber by carrying the scab organism from the soil to the tuber.

Studies of the life history and morphology of the potato flea beetle are of no great importance in solving this problem. Several investigators have described the life history quite fully. Hoerner and Gillette (*2*) made a study of the flea beetle in Colorado and described the damage done to plants and tubers. Johannsen (*3*), Webster (*8*), Britton (*1*), and Stewart (*7*) described certain types of flea-beetle injury. More recently Webster, Baker, and Hanson (*9*) in their work on worm-track injury on potato tubers reported the type called "pimply" potatoes and the "sliver" type as causing heavy damage in certain sections of Washington. MacMillan and Schaal (*6*) reported serious injury to tubers in Colorado resulting from infection of the worm tracks with the common scab fungus. However, none of these investigators mentioned the manner in which the worm tracks become infected. Leach (*4*) found that the seed-corn maggot (*Phorbia fusciceps* Zett.) is an important agent in the dissemination and hibernation of the potato blackleg organism (*Bacillus phytophthorus* Appel) and in the inoculation of its host. In a similar manner the flea beetle acts as an agent in scab infection of the potato tuber.

FIELD EXPERIMENTS

Measures for controlling the flea beetle are receiving considerable attention at the Colorado Potato Experiment Station at Greeley. Daniels,[4] working in the Greeley area, reports efficient control by the

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[3] Reference is made by number (italic) to Literature Cited, p. 258.

[4] Daniels, L. B. Unpublished data. Colo. Agr. Expt. Sta. 1933.

killing of the adults with dusts and sprays. However, as long as the larvae feed on the tubers the disfiguring worm tracks will continue to reduce the quality of the tubers.

Each season when the experimental plot at the potato experiment station at Greeley was dug, two types of worm-track injury were noted. The more common of these was the type described by MacMillan and Schaal (*6*) as being infected with common scab. Frequently worm tracks were observed that appeared as faint lines on the surface of the tubers. Cultures of this type of worm track proved the absence of scab. Often a tuber was found on which every worm track was infected with scab. This was especially true of lots that had received no seed treatment.

Ten hills of nearly mature potatoes were selected at random from each of two plots and carefully dug by hand. One plot had been grown from seed treated with 1:1,000 mercuric chloride for 1½ hours; the second plot had been grown from seed that received no treatment. The 10 hills from the treated lot contained 46 tubers, 28 of which showed serious worm-track injury; 51 tubers from the untreated lot showed worm-track injury of the "pimply" type.

All the tubers were taken to the laboratory and the worm tracks were cultured for scab, the method described by MacMillan and Schaal (*6*) being used. After the surface of a tuber was thoroughly washed the worm track was sterilized with hydrogen peroxide. The material to be cultured was then macerated with a scalpel, transferred to sterile water blanks, and from these to melted nutrient agar in Petri dishes. After 24 hours of incubation at 86° F. the dishes were examined, and then isolations were made. Of 31 worm tracks cultured from the untreated lot of tubers, 28 showed the scab organism. Of the 46 tubers from the treated lot 28 showed worm-track injury. Culture of these worm tracks showed scab present in 4 of the injured tubers.

As already mentioned, Leach (*4*) found that the seed-corn maggot carries the blackleg organism to potato seed pieces. It has been contended that the potato flea-beetle larvae carry both externally and internally the common scab organism from the soil to the tubers. The fact that there are fewer scab-infected worm tracks on tubers grown from treated seed than on those grown from untreated seed indicates a sterilizing effect on the soil by the chemicals used in the treatment.

LABORATORY EXPERIMENTS

CULTURE OF THE LARVAE

One hundred flea-beetle larvae were collected in the field by carefully removing them from tubers on which they were feeding. These tubers were grown from untreated seed. The larvae were placed in clean sterile sand and taken to the laboratory for further study.

After being carefully removed from the moist sand the larvae were divided into two groups of 50 each. Those in group 1 were disinfected with 1:1,000 mercuric chloride for 15 minutes, and were then washed through a series of sterile water baths. The larvae in group 2 were neither disinfected nor washed. The disinfected larvae were removed from the last water bath and transferred directly to marked areas on nutrient agar in Petri dishes. The larvae in group 2 were transferred directly from the sterile sand to marked areas on nutrient agar, then immediately removed and reserved for further study. The Petri dishes were placed in the incubator and held at approximately 74° F. for 48 hours. At the end of that time the plates were examined.

All the larvae disinfected with mercuric chloride were dead; none had moved from the marked area on the agar; no bacterial or fungus growth developed from the dead larvae. After 3 days the dead larvae were mashed on the agar. Growth developed from each of the dead mashed larvae. Culture of these growths showed the presence of bacteria and the common scab fungus in 42 of the 50 larvae; this indicates that the larvae harbored the scab organism internally.

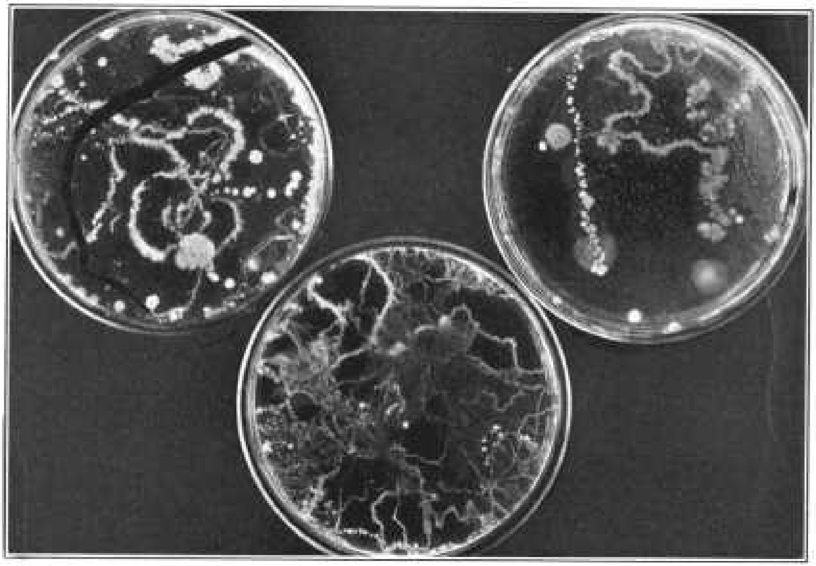

FIGURE 1.—Cultures showing development of bacteria and the scab organism (*Actinomyces scabies*) in the tracks made on nutrient agar by larvae of the potato flea beetle (*Epitrix cucumeris*).

Both fungi and bacteria developed on the agar where the unsterilized larvae had been placed. Culture of these growths showed the presence of the scab organism in 46 of the 50 larvae.

Of the 50 larvae retained from the untreated group 25 were washed through a series of 12 sterile water baths. After each washing the water adhering to the larvae was removed by placing the larvae on sterile filter paper. Twenty of the larvae survived these washings and when placed on nutrient agar in Petri dishes crawled about over the surface. The plates were placed in an incubator and kept there at 86° F. for 48 hours. Bacteria and the scab fungus developed on the agar where the larvae had crawled. Figure 1 shows the colonies of the scab fungus and bacteria growing from the tracks made on the agar by the larvae. Cultures of these colonies showed the scab organism to be present in the growths.

The remaining 25 larvae were placed on agar in Petri dishes without washing. They crawled about over the surface of the agar for several days. Fungus and bacterial growth developed and grew abundantly on the agar wherever the larvae had crawled. A larger number of unidentified fungi grew from the tracks of these larvae than from those washed in sterile water.

CULTURE OF THE EGGS

A large number of adult potato flea beetles were collected in the field and taken to the laboratory, where they were caged in lamp chimneys used in collecting the eggs (fig. 2). Both the top and bottom of the chimney were covered with cheesecloth, the large end resting on blotting paper that covered a sand base. Previous to the introduction of the adult flea beetles the entire chimney cage and the sand base were sterilized with steam. A small piece of potato tuber was placed in the cage for the beetles to feed on. The sand and blotting paper were kept moist by adding sterile water to the sand at frequent intervals. Eggs were found on the blotting paper 3 days after the beetles were caged. The insects laid their eggs through the cheesecloth on the blotting paper, where they were readily picked up.

FIGURE 2.—Lamp-chimney cage used to collect eggs of the potato flea beetle.

Several preliminary experiments were conducted to determine a suitable disinfectant for the eggs; table 1 shows the results. A commercial compound, hexylresorcinol solution (S. T. 37), used in two different dilutions, was found to be unsatisfactory. Treating with mercuric chloride for 1 minute was the most effective method of disinfection; stronger dilutions prevented the eggs from hatching. The time element was an important factor. When the eggs were left in the mercuric chloride solution for periods longer than 1 minute, the number of eggs hatching was greatly reduced. After the eggs were removed from the disinfectant they were washed through six sterile water baths. When taken from the last water bath they were placed on marked areas in plates containing hardened nutrient agar. Several types of media were tried in the preliminary experiments; the nutrient agar was found best suited for the studies to be made. Culture of the growths arising from the eggs that did not prove to be surface-sterile showed that several species of bacteria were present, but they were not identified. No scab organisms were found in these growths.

TABLE 1.—*Results of culturing eggs of the potato flea beetle*

Disinfectant used	Period of treatment	Eggs treated	Eggs proved surface-sterile	Larvae emerging	Larvae from surface-sterile eggs showing no bacterial or fungus growth
		Number	*Number*	*Number*	*Number*
Mercuric chloride 1:1,000	2 minutes	50	50	4	4
	1 minute	50	47	20	20
	30 seconds	30	11	16	2
Hexylresorcinol solution (S.T. 37), commercial strength.		25	9	18	1
Hexylresorcinol solution (S.T. 37), 50 percent of commercial strength.		25	4	20	0

The larvae hatching from the surface-sterile eggs were picked up with a sterile needle and transferred to nutrient agar in Petri dishes. The larvae crawled about over the surface of the agar, but no bacteria or scab fungus developed on it.

Eggs that were transferred directly from the blotting paper to the nutrient agar showed growth of bacteria in every case. No scab fungus was found in the growths developing from the eggs.

GREENHOUSE EXPERIMENTS ON LARVAE AS CARRIERS OF THE SCAB FUNGUS

Larvae hatched from surface-sterile eggs under sterile cultural conditions were placed in soil close to small immature potato tubers growing in pots in the greenhouse in order to determine the relation of the larvae to dissemination of the scab organism. The soil had been sterilized with steam, and the seed had been treated with a 1:1,000 solution of mercuric chloride for 1½ hours before being planted. Two series of three pots each were used in this experiment and six flea-beetle larvae were placed in each of the six pots. Care was exercised in handling the sterile larvae, since they are easily killed. In series 2 the soil had been previously inoculated with cultures of common scab (*Actinomyces scabies*). In placing the larvae in the soil, the top inch of soil was removed, the larvae were placed about an inch from the growing tubers, and then the soil was replaced. The pots were set on the greenhouse bench and covered with cheesecloth cages. Soil moisture was maintained by adding sterile water frequently, for field observations have shown that the flea-beetle larvae prefer a soil with a relatively high moisture content.

TABLE 2.—*Results of placing surface-sterile flea-beetle larvae in uninoculated and in scab-inoculated soil containing growing potato tubers grown from disinfected seed*

[Six larvae were placed in each pot]

Series no.	Pot no.	Soil treatment	Tubers showing worm tracks	Presence of scab organism in worm tracks
			Number	
1	1	Sterilized; not inoculated	2	−
	2		3	−
	3		0	−
2	1	Sterilized; inoculated with scab organism	3	+
	2		2	+
	3		1	−

The plants were allowed to mature. The period between the introduction of the larvae and the maturity of the plants was 27 days. At the end of this period several small tubers were removed from each pot and the presence or absence of worm tracks noted. Table 2 shows the results of this experiment.

The tubers grown in the scab-inoculated soil (series 2) showed worm tracks that were rough and pimply (fig. 3), whereas those grown in the sterilized uninoculated soil (series 1) showed worm tracks that in most cases were but faint lines on the surface (fig. 4). Culture of the worm tracks on the tubers grown in the scab-inoculated soil (series 2) showed the presence of the scab fungus in 2 of the 3 pots. No scab was found in the worm tracks on the tubers grown in series 1.

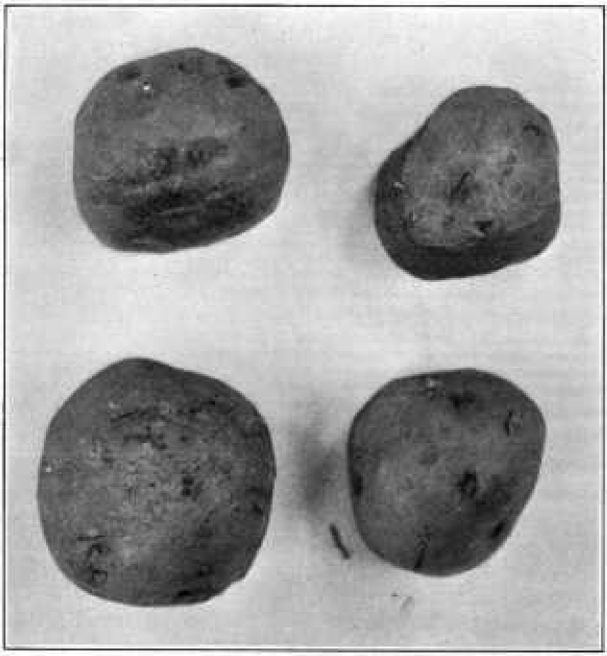

FIGURE 3.—Tubers grown from treated seed in soil inoculated with the scab organism (*Actinomyces scabies*). Surface-sterile flea-beetle larvae that had been placed in the soil made the worm tracks that became infected with the scab organism.

A second experiment involved the transfer of surface-sterile larvae from scab-inoculated soil to sterile soil. Six pots were used in 2 series of 3 pots each. The soil in each pot had been sterilized with steam previous to the planting of treated seed. The soil in the three pots in series 2 was inoculated with cultures of common scab before the seed was planted. Six sterile larvae were placed in the inoculated soil and allowed to remain there for 2 days. They were then carefully transferred to the uninoculated sterilized soil, where they were placed close to small growing tubers. These tubers were harvested 4 weeks after the larvae were placed in the soil. Several in each pot showed worm tracks. Of the 12 tubers taken from the three pots, 6 showed the rough, pimply type of worm-track injury. Cultures of the worm tracks showed the common scab organism to be present.

CONCLUSIONS

The potato flea beetle (*Epitrix cucumeris*) causes considerable damage to the potato plant by feeding of the adults on the foliage and the feeding of the larvae on the tubers. Investigators (*6*) have shown that larval injuries to the tubers, commonly called worm tracks, become infected by the common scab fungus (*Actinomyces scabies*), thereby reducing the salability of the tubers. On tubers grown from untreated seed, scab lesions in the worm tracks were common, whereas on tubers grown from seed treated with a 1:1,000 solution of mercuric chloride for 1½ hours no worm tracks of the rough pimply type characteristic of scab infection appeared.

The scab organism is found in practically all soils in the potato-growing areas of Colorado. The worm-track injury offers a suitable point of attack for this organism. A part of the infection may result from direct contact with soil infested with the scab fungus. However, in carrying the scab organism, both internally and externally, the flea-beetle larvae serve as efficient agents of inoculation.

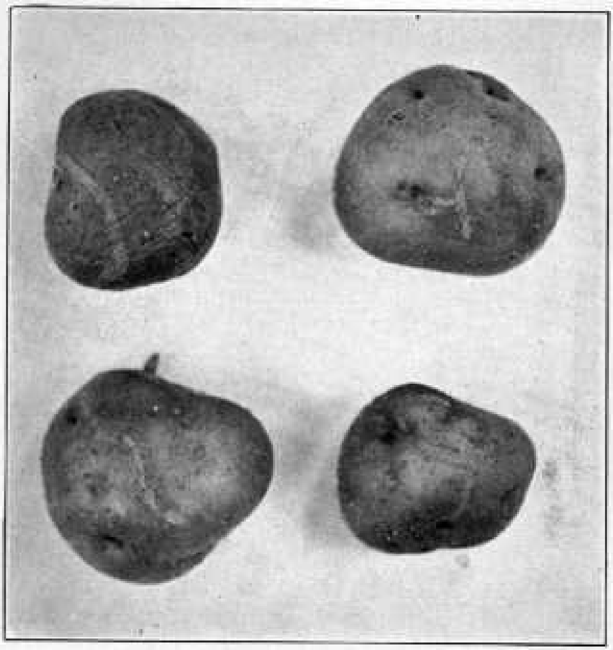

FIGURE 4.—Tubers grown from treated seed in sterilized soil. The worm tracks, made by surface-sterile flea-beetle larvae that had been placed in the soil, were not infected with the scab organism (*Actino mycescabiess*).

SUMMARY

The potato flea beetle (*Epitrix cucumeris* Harr.) continues to be a serious problem to potato growers in the Greeley area of Colorado. Worm tracks made on the tubers by the larvae become infected by the scab organism (*Actinomyces scabies* (Thax.) Güssow). This scab-infected type of worm track can be reduced by efficient seed treatment.

The flea-beetle larvae were found to carry the scab organism internally and externally under field conditions.

The scab organism was not found on the surface of the eggs of the potato flea beetle. Larvae hatching from disinfected eggs did not contain the scab organism, either internally or externally.

Worm tracks made by sterile larvae on potato tubers grown in sterilized soil did not become infected by the scab organism.

Larvae transferred from scab-inoculated soil to sterilized soil containing growing tubers made the scab-infected type of worm tracks on the tubers.

Potato flea-beetle larvae may cause scab infection of the potato tuber by carrying the scab organism from the soil to the tuber.

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