THE CAUSE OF DEEP-PITTED SCAB OF POTATOES

by
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SUMMARY

Streptomyces malachiticus, S. mirabilis, S. resistomycificus, S. carnosus, S. cinenochromogenes, S. albogresiolus, and four unidentified Streptomyces spp were isolated on tyrosine-casinate-nitrate medium (TCN) from deep-pitted scab lesions on the potato cultivars Green Mountain, Red Pontiac, Russet Burbank and Saco. One or more of these species of Streptomyces were found in 91% of the 400 lesions examined.

Streptomyces cinenochromogenes and unidentified Streptomyces spp isolate 11 were found in lesions on Russet Burbank tubers obtained from Wisconsin. All other tubers were grown in Washington. All identified species, except S. malachiticus and S. carnosus and two of the unidentified Streptomyces spp caused deep-pitted scab on Kennebec in artificially infected pasteurized soil. Re-isolations from deep-pitted lesions yielded Streptomyces spp similar in morphology to those originally inoculated.

Five genera of fungi Alternaria spp, Fusarium spp, Penicillium spp, Rhizopus spp, Trichoderma spp, several unidentified non-sporulating fungal types, and three bacterial genera Bacillus spp, Micrococcus spp, and Pseudomonas spp were isolated from deep-pitted scab lesions but none of these caused deep-pitted scab on tubers by artificial inoculation.

INTRODUCTION

Since 1970, approximately 6,000 acres have been removed from potato production due to deep-pitted scab in Walla Walla County in Washington. In 1977 our laboratory also received deep-pitted tubers from Franklin County in Washington and Hermiston, Oregon. Tubers with deep-pitted scab cannot be used for either fresh market or processing so represent a more serious loss than tubers with common scab which can be used for processing.

Differences between scab types and their causes have been discussed since Humphrey's (6) original observations (1, 2, 3, 4, 5, 7, 9). Different isolates or "strains" of Streptomyces spp have been reported to cause the different types of scab. The type of scab is apparently dependent on the potato cultivar, the environment, the pathogen and/or combinations of these factors (3, 9). Deep scab has also been thought to be the result of the combined action of Streptomyces scabies and chewing insects attracted to the lesions.

Controls effective for shallow scab do not control deep-pitted scab (Easton, unpublished data) (1, 4). The first step in disease control is the identification of the pathogen. Therefore the purpose of this study was to determine the causal organism of deep-pitted scab.

MATERIALS AND METHODS

Bacterial and fungal isolations from deep-pitted scab lesions on potato cultivars Russet Burbank and Kennebec were made on potato dextrose agar (PDA). A 0.5 mm thick tangential section of lesion tissue was placed on the surface of PDA. Hyphal tips of resulting fungi

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Information Paper _____. Project 1709. Washington State University, College of Agriculture, Agricultural Research Center.

were transferred onto fresh PDA. Bacterial growth from lesion tissue was streaked on PDA. Isolated colonies from this streaking were transferred and maintained on PDA slants.

Pathogenicity studies of the bacterial and fungal isolates were conducted in a 1.3 m^3 humidity chamber at room temperature and ~ 90% R.H. on wounded and unwounded storage tubers of the cultivar Russet Burbank.

Streptomyces spp isolates were obtained from lesions on the cultivars Green Mountain, Red Pontiac, Russet Burbank and Saco by a modification of Taylor's method (11). Tubers having deep scab lesion were washed under running water to remove loose, corky necrotic tissue. The entire lesion was exised and triturated with a few drops of saline solution in a flamed mortar. The resulting slurry was increased to a volume of 10 ml with saline solution and used as a stock solution from which subsequent dilutions were made. Dilutions of 10^{-4} to 10^{-7} were plated on modified tyrosine-casinate-nitrate media (TCN) (8). Growth typical of Streptomyces spp was transferred to PDA for sporulation. A spore suspension of each Streptomyces spp was made by washing the spores from the surface of the PDA cultures. Single colony isolates were then obtained by streaking the spore suspensions onto fresh TCN and then transferring resulting single colonies to PDA for maintenance. The isolates were preliminarily classified based on the source of isolation, melanin production on TCN medium, and colony morphology on PDA. Later, they were separated into species by M. Adang, Bioanalytical Lab, W.S.U. using electronmicroscopy and growth on differential media.

Streptomyces spp were tested for pathogenicity on the scab susceptible cultivar Kennebec in greenhouse and outdoor plantings. Kennebec was planted in naturally infected field soil or pasteurized (autoclaved for 4 hr. at 5 psi) field soil inoculated with selected Streptomyces spp isolates. Inoculum was increased for soil inoculation by transferring 100 ml of a one-week-old nutrient broth shake culture to a 1/2 pint Kerr® canning jar half filled with vermiculite and 500 ml of modified Richard's solution (10) previously autoclaved for 4 hrs. The cultures were then incubated at 22° C for 4 weeks.

RESULTS

Fungal and bacterial isolates from the deep-pitted scab lesions were not pathogenic on wounded and unwounded tubers of Russet Burbank in the humidity chamber.

Several species of Streptomyces were pathogenic on Kennebec (Tables 1 and 2). The isolates differed in their virulence on the Kennebec cultivar, causing either shallow or deep-pitted scab or both, depending on the species.

In greenhouse inoculations with isolates of the species of Streptomyces four of them produced deep-pitted scab. Two produced shallow scab and five, including S. scabies from the ATCC collection produced no lesions on Kennebec tubers after 61 days (Table 1).

Using another greenhouse method in which tubers were inoculated and observed during growth, isolates 2 and 3 produced deep-pitted scab in Kennebec after 40 days while isolate 12 produced only shallow lesions. S. scabies ATCC 3352 and the control produced no lesions. All isolates could not be tested because of space limitations of the observation chamber. The experiment was repeated with similar results.

In the outdoor planting in natural field soil both shallow and deep-pitted lesions occurred on the same tubers with all isolates except S. resistomycificus (Table 2). The percent of shallow scab varied depending on the isolate. S. scabies ATCC 3352, which was not virulent in greenhouse tests, caused shallow lesions on 100% and a few deep-pitted lesions on 43% of the tubers. The pasteurized control soil produced no lesions.

Table 1. Scab produced on Kennebec tubers by Streptomyces spp in greenhouse pots.

Isolate Number	Source of Isolate	Species of Streptomyces[1]	Type of Scab Produced	Disease Severity Index[2]
1	Red Pontiac	malachiticus	no scab	0
2	Russet Burbank	mirabilis	deep	2
3	Red Pontiac	--[4]	deep	3
6	Saco	resistomycificus	no scab	0
7	Russet Burbank	carnosus	shallow	4
8	Russet Burbank[3]	cinenochromogenes	shallow	2
9	Saco	albogresiolus	deep	3
10	Saco	--[4]	no scab	0
11	Russet Burbank[3]	--[4]	no scab	0
12	Green Mountain	resistomycificus	deep	6
3352	ATCC	scabies	no scab	0
Control			no scab	0

[1]Identification made by M. Adang (unpublished data).

[2]Disease severity was rated on a 0-10 scale; 0 = no lesions, 10 = entire tuber surface scabbed.

[3]These tubers were from Wisconsin. All others were from Washington.

[4]Not yet identified.

Table 2. Shallow and/or deep-pitted scab on Kennebec tubers after soil inoculation with selected Streptomyces spp in outdoor planters.

Isolate No.	Species of Streptomyces[1]	Shallow Scab[2]	Disease Index[3]	Percent Deep Scab[2]	Disease Index[3]
2	mirabilis	14.3	3	100	5
8	cinenochromogenes	57.1	6	100	3
12	resistomycificus	0	0	100	9
13	---[5]	100	5	100	5
3352	scabies (ATCC)	100	8	42.9	2
Control[4]		0	1	100	3
Naturally infected field soil		28.6	1	100	3

[1]Identified by M. Adang (unpublished data).

[2]Percent of tubers with scab 63 days after inoculation.

[3]Disease severity was rated on a 0-10 scale; 0 = no lesions, 10 = entire tuber covered with scab.

[4]Autoclaved soil.

[5]Not identified.

CONCLUSIONS

Species of Streptomyces isolates 2, 8, 12, 13 and S. scabies ATCC 3352 when tested in pasteurized field soil in large outdoor planters all produced slight to severe deep-pitted scab and except for isolate 12, produced shallow scab as well. The number of species of Streptomyces that caused both shallow and deep-pitted scab in our study (Tables 1 and 2) suggests that many soil species may be capable of causing scab given the proper environment and a susceptible host.

We have been able to (1) consistently isolate Streptomyces spp from deep-pitted scab lesions, (2) observe hyphae typical of Streptomyces spp in tissues immediately adjacent to lesions, (3) infect Kennebec tubers with the Streptomyces spp isolates and (4) re-isolate these Streptomyces spp from resulting deep-pitted lesions. We conclude that deep-pitted scab of potatoes in Washington and Wisconsin is caused by various species of Streptomyces but not necessarily S. scabies.

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