The pathogenicity of *Alternaria* spp. isolated from various apple tree organs to apple fruit

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Abstract

Pathogenicity of 206 isolates of *Alternaria* spp. to apple fruit was determined. The fungi were isolated from various apple tree organs: young and old leaves (May, November), flowers, flower buds, fruitlets, the skin of fully ripe apples, flower residues on fruits, twigs and cortex. The following fungi were isolated: *A. alternata*, *A. tenuissima* and *A. consorsiale*. *A. alternata* was the most common and the highest number of isolates was pathogenic to apples.

INTRODUCTION

Fungi belonging to *Alternaria* spp. are commonly known to cause diseases of many cultivated plants. They are being found increasingly more often on fruit trees and shrubs and on fruit. Barbetti (1980) isolated the fungi *Alternaria* sp. from the bunch rot of grapes, while Ceperonis and Butterfield (1982) established that it is the cause of sweet cherry rot. *A. tenuissima* causes leaf spot and fruit rot of highbush blueberry (Milholland, 1973), *A. alternata* is responsible for gooseberry black spot (Profic-Alwasiak and Szczygieł, 1980), and the leaf spot of peaches (Madaan et al. 1980). Fungi from the genus *Alternaria* were present in blossom-end rot of pears (Sommer, 1981) and their pathogenicity to apples and pears has also been demonstrated (Bondoux, 1969). Many authors stress the pathogenicity of these fungi for apples (Tweedy and Powell, 1960, 1962; Nagai and Takahashi, 1966; Mizuno and Takahashi, 1979). These authors, however, do not identify the species of *Alternaria* that cause apple rot. Ueono et al. (1975) report that *A. mali* Roberts is the cause of "blotch of apple" — this fungus was distinguished by them from *A. alternata*. Fungi from the genus *Alternaria* can be one of the pathogens causing calyx-end rot of apples (Bardinelli et al., 1981); they also often infect cores causing "Alternaria core rot" (Ellis, 1980). Ellis and Barrat

(1983) report that 95% of the fungi which they isolated from diseased apple cores was the fungus *A. tenuis* (syn. *A. alternata*). The nomenclature of *Alternaria* sp. has been somewhat changed recently, since it has been found that *A. longipes* (Ellis, Eveth) Malon, *A. tenuis* C. G. Needs and *A. alternata* (Fr.) Keissler are synonyms, and a name *A. alternata* (Fr.) Keissler has been accepted for these three species (Lucas, 1971).

The aim of these investigations was to identify the *Alternaria* spp. occurring on the various organs of the apple tree and to determine their pathogenicity to apple fruits.

MATERIAL AND METHODS

Samples of tree organs for fungi isolation were taken from the apple trees growing in the Experimental Stations at Miłobądz, at Dąbrowice and in the Pomological Orchard in Skierniewice. Isolations were done from seemingly healthy young and old leaves (May, November), flower buds, flowers, fruitlets, fruits, flower remnants on fruits and fruitlets, twigs and cortex. The 206 isolates of *Alternaria* spp. were identified and tested. The fungi were determined according to the characteristics given by Neergard (1945) and Ellis (1971, 1976).

The pathogenicity of the isolates was established after infection of apples cv. Starkrimson: the disks of the skin, each of 5 mm in diameter, were removed from two sides of the apple, next similar discs from a five day-old culture of the fungus, growing on PDA, was placed over these place and covered with polyethylene foil. Twenty infections were made with each isolate. After ten days of incubation at 20°C and 90% RH, the diameter of the rot spot was measured, and the pathogenicity of the isolate was determined on the basis of its size. Five classes of pathogenicity were established: I — when the diameter of the rot spot was from 6.0 to 6.5 mm, II — 6.6 to 8.0 mm, III — 8.1 to 10.0, IV — 10.1 to 14.0 and V — when the rot spot's diameter exceeded 14 mm. The diameter of the rot spot was measured again after 20 days, and from the difference of the two values, conclusions about the rate of spreading of the fungus were drawn. Six classes of the rate of spreading of the fungus were established: I — when the difference was between 0 to 0.5 mm, II — 0.6 to 1.0, III — 1.1 to 1.5, IV — 1.6 to 2.0, V — 2.1 to 3.0 and VI — when the difference exceeded 3.0 mm.

RESULTS

Three species of *Alternaria* were found to be present in the 206 studied isolates of this genus obtained from apple trees: *A. alternata* (Fr.) Keissler, *A. consortiale* (Thum) Groves, Highes and *A. tenuissima* (Kunze ex Pers.) Wiltshire. *A. alternata* was the most frequent — 133 isolates, then *A. consortiale*

— 43 isolates and *A. tenuissima* — 30 isolates. *A. consortiale* did not occur on twigs and cortex of apple trees and *A. tenuissima* was not found on the cortex of apple trees. All three species of *Alternaria* were found on the remaining organs, although with various frequencies. *A. alternata* and *A. tenuissima* were found equally often on leaves and fruit, while *A. consortiale* was found mainly on leaves (Table 1). Large differences in the pathogenicity

Table 1

The pathogenicity of various isolates of three *Alternaria* spp. to apples; the number of isolates in each class is given

Species of fungus	Source of isolate	Pathogenicity classe				
		I	II	III	IV	V
<i>A. alternata</i>	apples and remnants of flower organs	33	19	5	2	—
	fruitlets and remnants of flower organs	1	—	1	—	—
	young leaves	17	12	6	2	—
	old leaves	11	3	2	1	—
	lower buds	—	—	1	1	—
	twigs	2	—	—	1	—
	cortex	1	1	1	—	—
	flowers	4	3	—	2	1
	total	69	38	16	9	1
<i>A. consortiale</i>	apples and remnants of flower organs	3	—	—	—	—
	fruitlets and remnants of flower organs	1	—	—	—	—
	young leaves	24	7	2	1	—
	old leaves	—	—	—	—	—
	flower buds	2	—	—	—	—
	twigs	—	—	—	—	—
	cortex	—	—	—	—	—
	flowers	2	1	—	—	—
	total	32	8	2	1	—
<i>A. tenuissima</i>	apples and remnants of flower organs	7	5	—	—	—
	fruitlets and remnants of flower organs	—	—	1	—	—
	young leaves	7	2	1	—	—
	old leaves	1	—	—	—	—
	flower buds	—	2	—	—	—
	twigs	—	1	—	—	—
	cortex	—	—	—	—	—
	flowers	2	1	—	—	—
	total	17	11	2	—	—
Total		118	57	20	10	1

of the particular isolates towards apples were also found. From among the 133 isolates of *A. alternata*, 69 were little pathogenic and belonged to class I of pathogenicity, 38 showed greater pathogenicity (class II), 16 were classified in class III, while 9 in class IV. Only one isolate from a flower exhibited the greatest pathogenicity since after ten days the diameter of the rot spot exceeded 14 mm. The isolates of *A. tenuissima* and *A. consortiale* were much less pathogenic; no *A. tenuissima* isolate and only one *A. consortiale* isolate were assigned to pathogenicity class IV. The pathogenicity of an isolate was not correlated with the place from which it was taken, since both weakly and strongly pathogenic isolates were obtained from various locations and organs of the plant. Fungi from the genus *Alternaria* were isolated most often from young leaves and flower remnants on the apple. The rate of spreading of the rot spot evaluated on the basis of the difference in the size of the spot made it possible to establish how the fungus settled the various apple tissues. The rot spots caused by *A. alternata* spread the fastest, since 6.5% of the isolates made rot spots that were over 3 mm larger in diameter after 20 days than after 10 days, while not a single *A. consortiale* isolate equalled the spreading rate of *A. alternata* and only 3% of *A. tenuissima* isolates reached that rate (Table 2). On this basis it can be supposed that the main pathogen occurring on apples is *A. alternata*, since this species was the most frequent on apple trees and showed the greatest pathogenicity to their fruits.

Table 2

The development of the *Alternaria* rot spot on apples depending on the species and isolate of the fungus; the number of isolates in each class of growth is given

Species of fungus	Classes of growth of rot spots (mm)					
	I 0-0.5	II 0.6-1.0	III 1.1-1.5	IV 1.6-2.0	V 2.1-3.0	VI over 3 mm
<i>A. alternata</i>	68	26	13	8	9	9
<i>A. consortiale</i>	31	4	6	1	1	0
<i>A. tenuissima</i>	19	6	2	1	1	1

DISCUSSION

During recent years, it has been noticed that fungi *Alternaria* spp. are becoming increasingly responsible for diseases occurring in stored apples. These saprophyte fungi presently are turning to pathogens of fruit. In this case, an important role was probably played by systemic fungicides used in numerous sprayings of fruit trees. They could eliminate a lot of antagonistic microorganisms of this group of fungi from the environment. The increasing importance of such diseases as moldy core of apple, calyx-end rot or apple

spot diseases, was the reason for seeking the source of infection of fruit. The observations were begun by determining which species of *Alternaria* were present on the various organs of trees and establishing their pathogenicity to apples. Further stages of investigations will include detailed studies of each of these diseases.

CONCLUSIONS

1. Three *Alternaria* spp. are present on different organs of apple trees, they are: *A. alternata* (Fr.) Keissler, *A. consortiale* (Thum) Groves, Highes, and *A. tenuissima* (Kunze ex Pers) Wiltshire.
2. The most common on apples is *A. alternata* (Fr.) Keissler.
3. *A. alternata* is the most pathogenic to apples.
4. Pathogenicity of *Alternaria* spp. to apples significantly varied among the isolates of the same species.

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Patogeniczność w stosunku do jabłek grzybów z rodzaju *Alternaria* wyizolowanych z różnych organów jabłoni

Streszczenie

Zbadano 206 izolatów grzybów z rodzaju *Alternaria* pochodzących z różnych organów jabłoni jak: młode i stare liście, pąki kwiatowe, kwiaty, zawiązki, owoce, resztki kwiatowe znajdujące się na owocach i zawiązkach, krótkopędy i kora. Stwierdzono, że grzyb *Alternaria alternata* (Fr.) Keissler był najliczniej reprezentowany i najwięcej izolatów tego gatunku wykazało dużą patogeniczność w stosunku do jabłek; pozostałe wyizolowane gatunki to *A. tenuissima* (Kunze ex Pers.) Wiltshire oraz *A. consortiale* (Thum) Groves, Hughes.