POSSIBLE ROLE OF FUNGAL VIRUSES IN THE DISTRIBUTION AND SPREAD OF THE DUTCH ELM DISEASE FUNGUS[1]

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Abstract. Double-stranded RNA, which is characteristic of fungal viruses, has been detected previously in isolates of *Ceratocystis ulmi*. Isolates from states with a long history of Dutch elm disease contained dsRNA, whereas isolates from states with a short history of the disease had no dsRNA. It is suggested that fungal viruses may be a factor in the distribution and spread of *C. ulmi*.

It has become apparent in recent years that the occurrence of viruses in fungi (mycoviruses) is widespread. Such viruses may affect the distribution and severity of certain fungal diseases.

Hypovirulent (believed to be virus-infected) strains of the chestnut blight fungus, *Endothia parasitica*, can protect trees against virulent (virus-free) strains (5, 12). The hypovirulent strains contain double-stranded ribonucleic acid (dsRNA) which is the genetic information of most fungal viruses, and this dsRNA is transmitted to the virulent strains by hyphal anastomosis (3). Recently virus-like particles were found associated with the dsRNA in at least one hypovirulent strain of *E. parasitica* (4). It appears that dsRNA or a dsRNA virus in Italy has protected stands of European chestnut against chestnut blight, changing virulent strains of *E. parasitica* into hypovirulent ones (1, 8, 11).

We discovered that dsRNA is contained in some isolates of the Dutch elm disease (DED) fungus *Ceratocystis ulmi* (Buis.) Moreau and that the dsRNA appears to affect its pathogenicity (9 and Pusey and Wilson, unpublished). We wondered whether the dsRNA has affected or is affecting the natural spread of DED in the United States. So we tried to determine whether the presence of dsRNA in our *C. ulmi* isolates was related to the length of time disease had been present in the states where those isolates were collected (Table 1, Fig. 1). We assumed that more aggressive isolates could spread faster than less aggressive ones. If this should be true, and if viruses contributed to the lower pathogenicity of less aggressive isolates, then more virus-free isolates should be found in states where the disease has been present for a "short time" than in states where it has been present for a "long time."

The results of this study seem to support our idea. Isolates from states with the longest history of DED contained dsRNA. Except for isolate VA, all isolates from states where DED was unknown prior to 1955 contained no dsRNA.

Given an east to west spread, Colorado seems out of place on the distribution map (Fig. 1) with its report of DED earlier than reports for states eastward, including Nebraska, Kansas, and Oklahoma. Dutch elm disease was discovered in several areas of Denver in 1948 (10), but was not found again in Colorado until 1968 (7). Interestingly, one of the Colorado isolates (CO2) contained 5 dsRNA components which banded in polyacrylamide gels in a pattern identical to that exhibited by one of the Massachusetts isolates

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Table 1. Comparison of years when Dutch elm disease was first discovered in states of the United States with the number of dsRNA components detected in *Ceratocystis ulmi* isolates from those states.

Year[a]	State	Year of Isolate Recovery[b]	Isolates	No. dsRNA species[c]
1930	Ohio	1961	OH	2
1934	Virginia	1970	VA	0
1941	Massachusetts	1970	MA1, MA2	1, 5
1946	Tennessee	1970	TN	7
1948	Colorado	1970	CO1, CO2	2, 5
1950	Illinois	1970	IL	1
1952	Maine	1970	ME	1
1952	Missouri	1970	MO	2
1956	Wisconsin	1970	WI	0
1957	Iowa	1970	IA	0
1962	North Carolina	1965	NC	0
1968	Alabama	1970	AL	0
1969	North Dakota	1969	ND	0

[a] *Year of first discovery of Dutch el disease (DED) in each state according to Davis (2), Holmes (8), and Whitten and Swingle (15).*

[b] *Year in which isolates tested for dsRNA were recovered from their respective states according to L.R. Schreiber (personal communication).*

[c] *Number of dsRNA species was determined by electrophoresis of nucleic acid samples in 2.4% polyacrylamide gels at 5 mA/gel for 4.5 hours.*

(MA2) (9). The Tennessee isolate (TN) had a similar banding pattern for 5 dsRNA species, although it had two additional dsRNA components not detected in MA2 and CO2. It can be speculated that a *C. ulmi* strain containing dsRNA was introduced (perhaps via man's activities rather than natural spread) into Colorado before or during 1948 from some area in the eastern half of the United States and persisted unnoticed because of its lower pathogenicity.

Our findings although not conclusive present a new factor that should be considered in the spread and distribution of Dutch elm disease.

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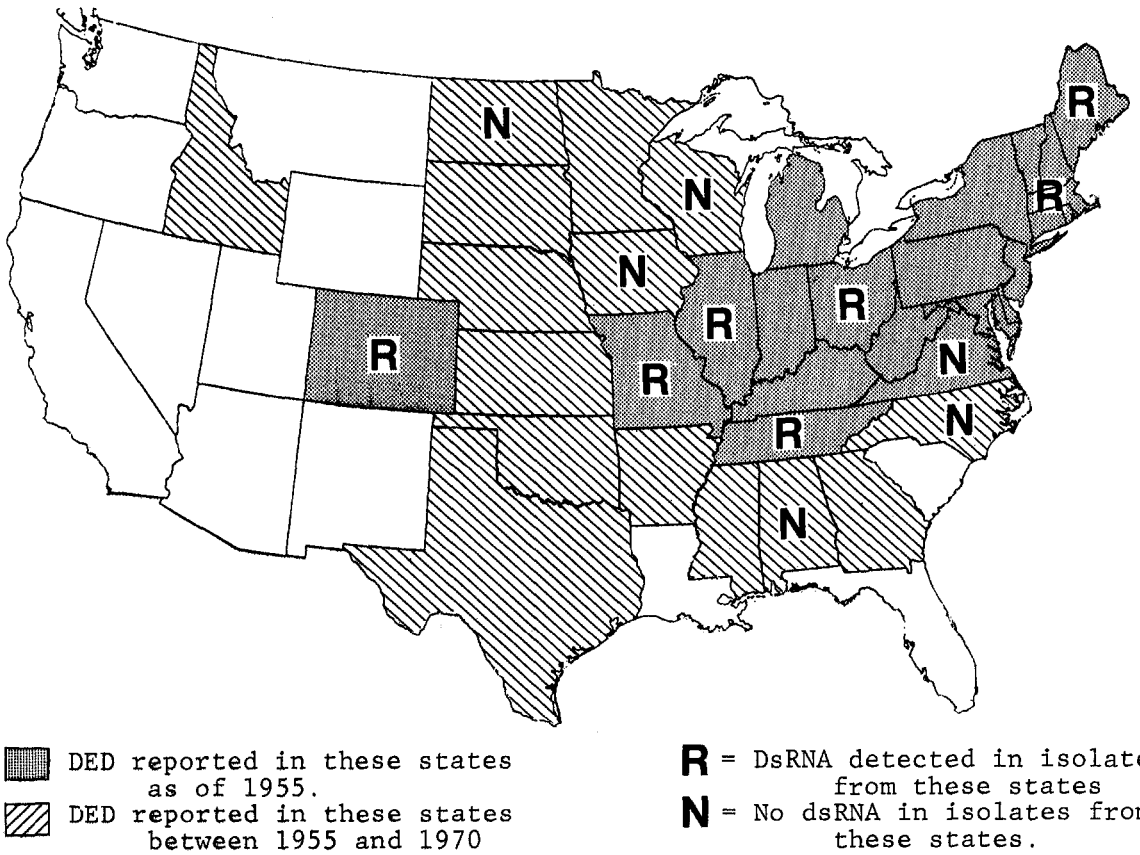

Fig. 1. Comparison of the distribution of Dutch elm disease (DED) in the United States before and after 1955 and with the distribution of dsRNA in *Ceratocystis ulmi*.

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