RECENT DEVELOPMENTS IN UNDERSTANDING EARLY DYING OF POTATO VINES -- THE ROLE OF VERTICILLIUM DAHLIAE

by
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Potato yields are decreasing in the irrigated circles of Oregon's Columbia Basin, and the decrease has been positively correlated with early dying symptoms. This phenomenon usually occurs where potatoes have been cropped for several years, but early dying may occur in fields new to potato production. In the Pacific Northwest, Verticillium wilt (causal agent, Verticillium dahliae) is the major fungal disease causing early dying symptoms, but other pathogens have been associated with the early dying syndrome, including Erwinia carotovora, Colletotrichum atramentarium and Fusarium spp., causal agents of blackleg and stem soft rot, black dot, and "Fusarium wilt", respectively.

In 1977 fields of Norgold Russets which showed early dying symptoms were rated visually using a scale of 0% to 100%, where 0% = no symptoms and 100% = all plants exhibiting some degree of early dying. Stem isolations revealed a high positive correlation ($R^2 = 0.83$) between early dying symptoms and incidence of V. dahliae.

A disease survey was conducted during the 1977 and 1979 growing seasons to determine the incidence of soil-borne fungal diseases of potatoes grown in the irrigated circles of the Columbia Basin. In 1977, 39 circles with cropping histories of 1, 2, 3 and 4 years in potatoes were sampled. In 1979, 5 of the same circles with only one previous year of potatoes were sampled again.

The only potato fungal pathogen that increased with each potato crop regardless of variety was V. dahliae (Fig. 1). In first year fields, 6.3% of the plants were infected by V. dahliae whereas in fourth year fields the incidence ranged from a low of 16% (one circle only) to a high of 100%. The average incidence of V. dahliae for fourth year fields was 74%.

Five circles of Russet Burbank were sampled for the presence of V. dahliae in both 1977 and 1979. Winter wheat was the rotation crop for each of these circles in 1979. The incidence of V. dahliae increased from 4.25% to 49.25%. Apparently a single year of winter wheat does not adequately delay or prevent the build-up of Verticillium inoculum in the soil. Also the greatest increase in incidence of this disease probably occurs during the first two years of potato production.

The rate at which V. dahliae infection increases with cropping years to potatoes can be calculated from incidence data and is termed the apparent infection rate. Apparent infection rates were 1.17 and 1.34 per year for Norgold Russet and Russet Burbank, respectively, and this indicates that during the first four years of potato production the incidence of infection by Verticillium more than doubled each year.

However, incidence of the pathogen fails to adequately measure disease severity on a field or plant basis. Consequently, studies were initiated in 1978 to evaluate disease severity in Norgold Russet and Russet Burbank potatoes.

Plots were established in two circles in the Columbia Basin of Oregon. One circle, new to potato production, served as the control plot because soil-borne diseases generally are not a limiting factor in first year circles. In a second circle, potatoes had been cropped for three of the previous four years with wheat the only rotation crop, and in 1977 early dying symptoms were apparent in 95% of the potato plants. To eliminate variability associated with

different seed lots, seed from the same source was planted at both locations. Fertilizer and pesticide programs were similar, and 41 and 36.5 inches of water were applied during the growing season on the new and old fields, respectively. Potato yield was used to estimate the effect of early dying disease.

Figure 1. The incidence of Verticillium dahliae in irrigated circles or Norgold Russet and Russet Burbank potatoes after 1, 2, 3, and 4 years of production.

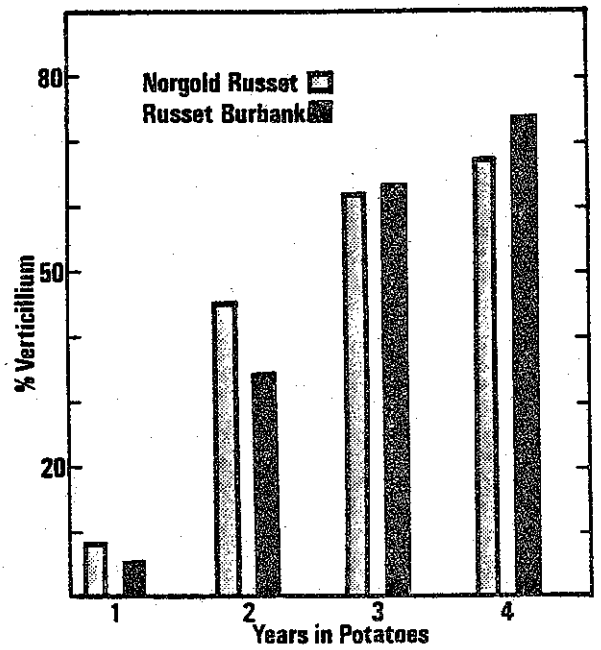
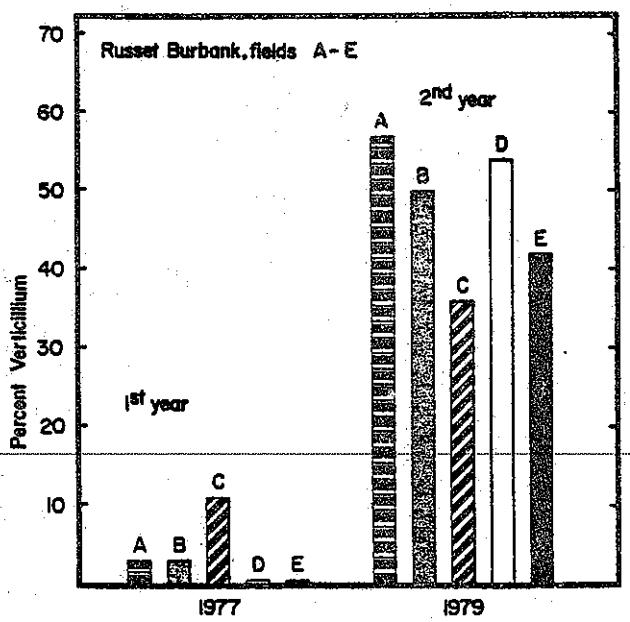
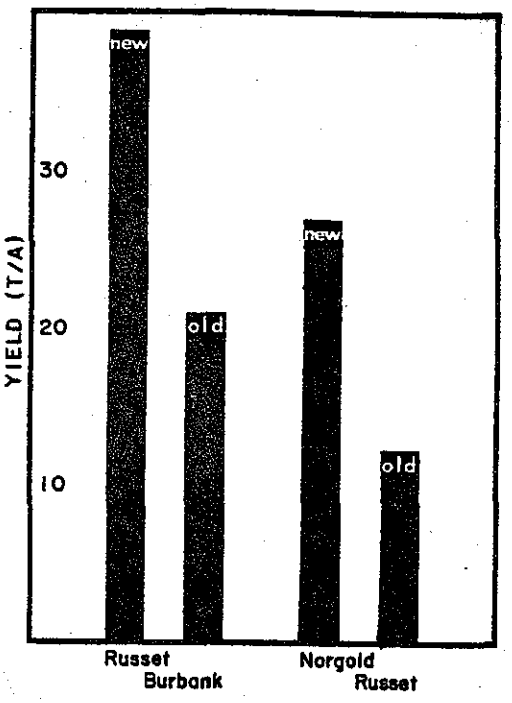


Figure 2. The incidence of Verticillium dahliae in 5 irrigated circles of Russet Burbank potatoes which were in their first year of potato production in 1977 and their second year of potato production in 1979.



In the new field, the yield of Russet Burbank was 38.8 T/A and Norgold Russet yielded 26.9 T/A, whereas in the old field the yields were 21.3 T/A and 12.6 T/A, respectively. This amounted to yield reductions of 45% for Russet Burbank and 53% for Norgold Russet in the old field (Fig. 3).

Figure 3. Yield of Russet Burbank and Norgold Russet in a field new to potato production and in a field in its fourth year of potato production.



The incidence of Fusarium spp., C. atramentarium, E. carotovora, and V. dahliae and the severity of infection (units of pathogen/cm stem tissue) by C. atramentarium and V. dahliae were determined in plants from the new and old fields.

Incidence of Fusarium spp. and E. carotovora was significantly higher in both varieties grown in the new field whereas the reverse was true for the incidence and severity of C. atramentarium infection (Table 1).

Incidence and severity of V. dahliae infection differed significantly between the new and old fields. In the new field, the mean percentage of plants infected was 12% for Russet Burbank and 17% for Norgold Russet, while severity of infection in these plants was 11 and 204 units of V. dahliae per cm stem tissue, respectively (Fig. 4 and 5). In the field that had been in potato production in previous years, about 90% of the plants of both varieties were infected by V. dahliae, and severity of infection was extremely high (Fig. 4 and 5). The higher incidence and severity of Verticillium infection in the older field was probably the result of a higher level of soil-borne inoculum in this field. The new field averaged 9 microsclerotia of V. dahliae per gm of soil whereas there were 530 microsclerotia per gram in soil from the old field.

Table 1. Incidence of Erwinia carotovora, Fusarium spp. and Colletotrichum atramentarium, and severity of infection by C. atramentarium in Russet Burbank and Norgold Russet grown in a new and old field.

Pathogens	Russet Burbank		Norgold Russet	
	New Field	Old Field	New Field	Old Field
	Percent of plants from which pathogen was isolated			
Erwinia carotovora	0.9	0	4.2	3.2
Fusarium spp.	12.0	10.0	19.2	2.0
C. atramentarium	12.0	30.0	5.0	14.0
	Number of C. atramentarium units/cm stem tissue			
C. atramentarium	2250	4707	198	1125

Figure 4. Incidence of Verticillium dahliae in Russet Burbank and Norgold Russet in a field new to potato production and a field in its fourth year of potato production.

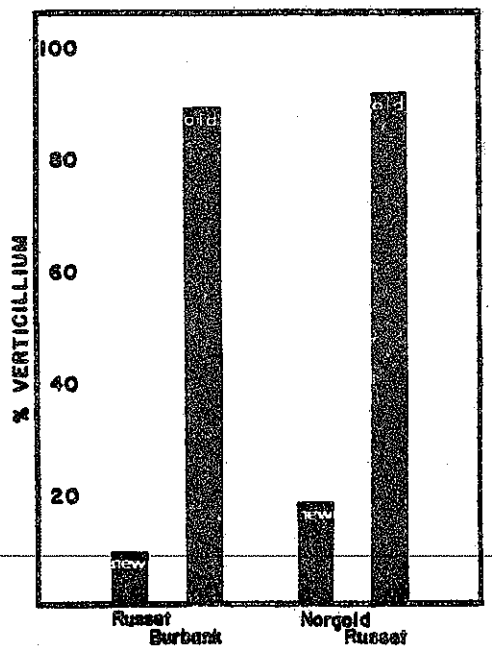
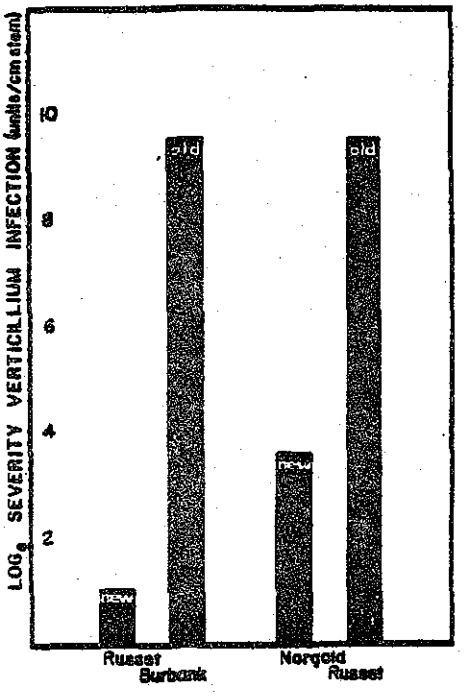


Figure 5. Ln severity of Verticillium dahliae infection in Russet Burbank and Norgold Russet in a field new to potato production and a field in its fourth year of potato production.



Eighty-nine percent of the large differences in potato yields between the old and new field could be explained by the interaction of incidence and severity of Verticillium infection (Fig. 6). No other diseases were associated significantly with these yield differences between these fields. In fact, neither incidence nor severity of Verticillium infection alone was a reliable estimate of subsequent yield reductions. For example, if 90% of the plants were infected with V. dahliae, but the severity of infection was low (e.g., 10 units/cm stem), yield reduction would be slight. Similarly, if infection severity was high (e.g., 15,000 units/cm stem), but relatively few plants were infected ($<10\%$), yields would not be depressed significantly. Only when incidence and severity of Verticillium infection are high, would yields be severely reduced. An experimental model that includes the two expressions of Verticillium infection provides the most reliable estimate of yield reductions from early dying disease.

The experimental model was used to evaluate the potato yield differences obtained with the two potato varieties. The model indicates that the incidence and severity of V. dahliae infection that developed in the two varieties from the same soil inoculum level caused a greater yield loss in Norgold Russet than in Russet Burbank. In the old field, the yield reduction in Norgold Russet caused by V. dahliae did not increase significantly as Verticillium infection increased, i.e., the lower levels of Verticillium infection caused as much yield reduction as the higher levels. The highest incidence of V. dahliae observed in the old field was 92% for Norgold Russet. Extrapolating the incidence to 100% and severity to levels higher than observed, the model suggests no further yield reduction in Norgold Russet variety from V. dahliae. With Russet Burbank, however, further yield depression could occur from this disease could occur from this disease. Russet Burbank is generally less susceptible than Norgold Russet to early dying as measured by yield reduction. Consequently planting Norgold Russet potatoes on new ground rather than on land that has a Verticillium wilt problem is critical for better yield.

Figure 6. The relationship between potato yield and the interaction of incidence and In severity of Verticillium dahliae infection in Norgold Russet and Russet Burbank potatoes.

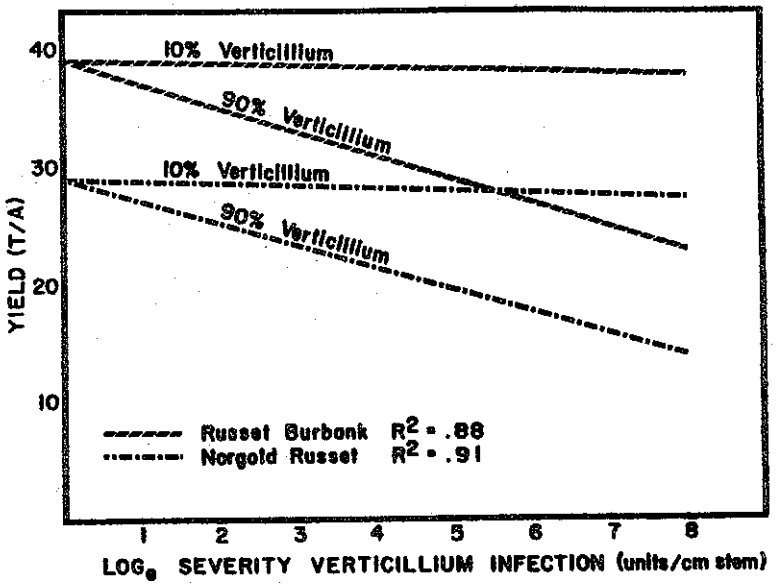


Table 2. Incidence of Verticillium dahliae infected plants and yield of Russet Burbank and Norgold Russet potatoes that died prematurely, 1977 and 1979.

Field	Variety	Year	% Verticillium	Yield (T/A)
1	N	1979	4	17
2	N	1977	23	13
3	N	1977	6	17
4	N	1977	30	16
5	N	1977	31	19
6	R	1977	6	23
7	R	1977	16	20

N = Norgold Russet
R = Russet Burbank

The model also states that with a low incidence of Verticillium infected plants and a high severity of infection, yield will be reduced only slightly. However many fields of potatoes which died prematurely had low yields, even though the incidence of Verticillium infected plants was low (Table 2). Therefore, V. dahliae was not responsible for the early vine death and subsequent reduced yields. Other pathogenic organisms, cultural practices, and environmental factors may be contributing to this symdrome called early dying.

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