CIS 977

Verticillium wilt of potato

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Verticillium wilt of potato may be caused by either of two soilborne fungal species — *Verticillium dahliae* (microsclerotial form) or *Verticillium albo-atrum* (dark mycelial form). In Idaho and other arid growing regions of the West, this disease is caused by *V. dahliae*.

The host range of *V. dahliae* is broad. It commonly grows on the roots of a wide range of nonhost plants including grasses. The fungus infects many broadleaf plants and numerous weed species. Recent studies show that even plants native to the Idaho desert (saltbush, rabbitbrush, salt sage, and fringed sagebrush) may serve as host plants.

Symptoms and damage

Initial symptoms of the disease in potato are a slight downward growth of petioles and a yellowing of lower leaves. Leaf yellowing proceeds up the stem, often on just one side. The upper leaves are the last to show symptoms. Leaf yellowing is followed by wilt, browning, necrosis, flagging, and death of the stem (fig. 1). Discoloration of the vascular conducting tissue of the plant is commonly associated with *V. dahliae* infection. Stem-end discoloration in tubers may occur in severe cases. This symptom sometimes is confused with net necrosis caused by the leafroll virus.

Depending on severity, time of occurrence, growing season, and variety, potato yields and tuber size may be substantially reduced. Yield losses of 50 to 100 hundredweight (cwt) per acre are not uncommon for Russet Burbank. Losses of up to 60 percent have been documented in southeastern Idaho.

Fig. 1. Symptoms of severe Verticillium wilt on Russet Burbank potato.

V. dahliae survives in the soil from year to year as several types of resting structures, including small, compact, fungal masses called microsclerotia. These structures protect the fungus under adverse conditions such as drought and cold. In the spring, they germinate and invade roots, mostly by direct penetration. The fungus then colonizes the plants starting from the roots and reaching to the top and even into the leaves.

After several successive potato crops, the soilborne inoculum level may be high. This inoculum is long lasting in soil.

Rotation practices have not been shown to eliminate this pathogen from soil. In "old" potato ground, the short rotations commonly followed in Idaho (2 to 3 years) do not reduce levels of the pathogen.

Potato seed also may provide a source of inoculum, but its importance is questionable. Recent unpublished studies by the University of Idaho demonstrate that even when Verticillium-free seed is introduced to virgin ground, *V. dahliae* infection in potato stems commonly appears by season's end. This may be explained by the ability of soilborne *V. dahliae* microsclerotia to survive air drying as it moves from field to field with high winds.

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Association with other pathogens

Although the root lesion nematode *Pratylenchus penetrans* reportedly interacts with *V. dahliae* to accelerate disease severity, its presence in Idaho is relatively rare. Therefore, we currently do not regard *P. penetrans* as a significant factor for Verticillium wilt in Idaho. The most commonly occurring root lesion nematode in Idaho is *P. neglectus*, but it is not yet recognized as an important factor in the development of Verticillium wilt.

In contrast to the root lesion nematodes, *Colletotrichum coccodes*, the causal organism of the blackdot disease, enhances wilt severity and causes yield losses greater than with *V. dahliae* alone

Control and disease suppression

Sanitation

Potato stems provide the primary source of soilborne inoculum. Where local laws permit, stem burning is recommended. The effectiveness of this practice depends upon complete burning of stems.

Resistance

When compared with other varieties (table 1), Russet Burbank has a moderate degree of resistance to *V. dahliae*. Among varieties grown in Idaho, the most resistant are Gemchip (a chipping variety), Frontier Russet (an early variety), Ranger Russet, and Targhee.

Potato varieties of differing resistance to Verticillium wilt may differ in their degree of stem colonization. Levels of *V. dahliae* in plant tissue of susceptible varieties are higher than those found in resistant varieties. As a consequence, soilborne populations of *V. dahliae* may be higher (fig. 2). Therefore, it pays to plant potato varieties highly resistant to *V. dahliae*. Varieties may not only influence the present crop but future crops as well.

Table 1. Relative susceptibilities of potato varieties to Verticillium wilt.

Highly susceptible to susceptible	Moderately susceptible to moderately resistant	Resistant to highly resistant
Superior	Russet Burbank	Frontier
Norgold Russet	Butte	White Rose
Russet Norkotah	Atlantic	Ranger
BelRus	Monona	Sangre
Norland	Red LaSoda	Nooksack
Norchip	Lemhi Russet	Katahdin
Centennial Russet	Shepody	Norking
Kennebec		Gemchip
HiLite Russet		Russet Nugget
Gold Rush		Century Russet
		Chipeta
		Targhee

Cultural management

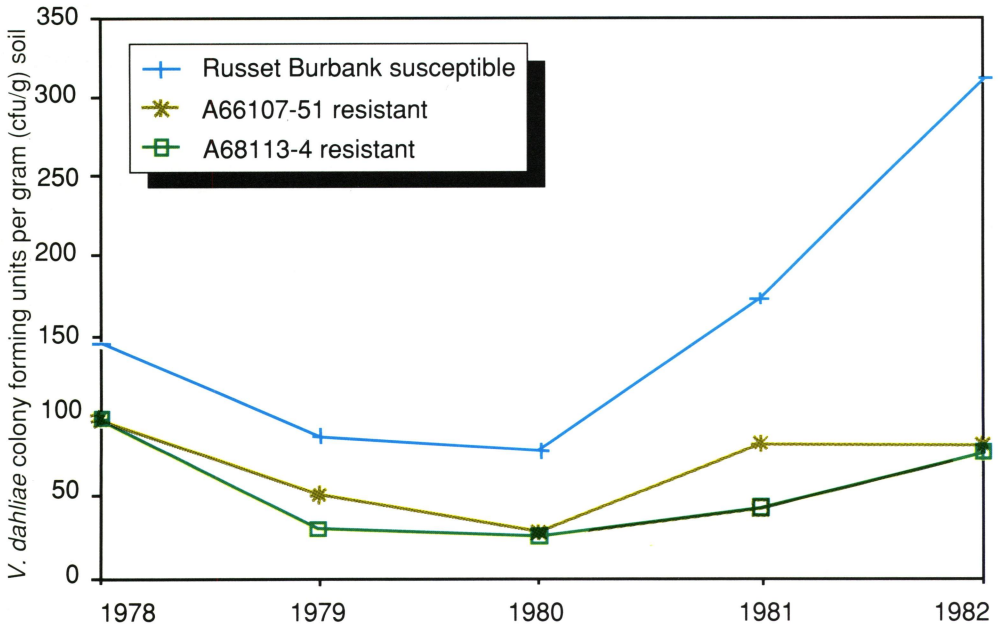
Studies in eastern Idaho demonstrate several cultural factors — relative salt content in soil, nitrate-nitrogen (NO_3-N), potassium (K), and phosphorus (P) in petioles — to account for as much as 71 percent of field variability related to the development of *V. dahliae* in stem tissue of Russet Burbank.

Irrigation — Verticillium wilt is less severe with sprinkler irrigation than with furrow (gravity) irrigation. Also subirrigation is associated with higher disease severity. In the Egin Bench area of eastern Idaho, disease severity in subirrigated fields is often higher than in sprinkler-irrigated fields. Soil moisture is more uniformly distributed under sprinkler irrigation, reducing the incidence of water stress.

As the season progresses (particularly beyond the flowering stage), moisture stress causes Verticillium-like symptoms to become more pronounced.

Although the reason for the relationship between severity of Verticillium wilt and irrigation methods is not known, an effect on nitrogen (N) availability and distribution is indicated. With furrow irrigation or subirrigation, N commonly accumulates within the upper 2 to 3 inches of the soil profile. In contrast, with sprinkler irrigation, N is distributed

Fig. 2. Relative effects of resistant and susceptible potato clones upon inoculum densities of *V. dahliae* in soil.



more uniformly throughout the soil. When N is less available to the plants' root systems because of leaching or poor distribution, disease severity may increase.

Nitrogen — Among all cultural factors, low N availability is most commonly associated with the incidence and severity of Verticillium wilt of potato. As the N availability increases, the colonization of plant tissue by *V. dahliae* decreases. Verticillium wilt in Russet Burbank is most severe when N is deficient. As N availability approaches the optimum for yield (about 18,000 ppm NO_3 -N in petioles during the first week of August), the disease severity in Russet Burbank decreases.

With subirrigation, N availability may improve significantly over granular-applied fertilizers with anhydrous ammonia (table 2).

The same relationship between available N and severity of Verticillium wilt has not been shown with Norgold Russet (an early maturing variety). Thus, a relationship can exist between the N response and variety.

Phosphorus — Greenhouse and field studies show *Verticillium* suppression with P treatments. As P concentrations in the soil increases to the optimum (fig. 3), the infestation by *V. dahliae* in potato stem tissue decreases.

Potassium — The effect of K on Verticillium wilt has not been documented for potato, but K has been reported to suppress Verticillium wilt in other crops (e.g., cotton, pistachio).

N and P interactions — Studies point to the importance of both N and P for the suppression of *V. dahliae* in stem tissue and soil. While either nutrient is important, it is more important that these nutrients be utilized optimally together.

Green manure treatments — Although current crop rotation practices are largely ineffective for the suppression of *V. dahliae*, green manure treatments are helpful. Green manure crops increase soil microbial activity substantially, which may suppress soilborne pathogens. Green manure crops of sweet corn and sudangrass have provided disease control following their use for 2 consecutive years.

Fig. 3. Relationship of P in soil to *V. dahliae* colonization in Russet Burbank apical stems (P concentrations determined in spring before planting and stems collected for *V. dahliae* colonizations at season-end in late August).

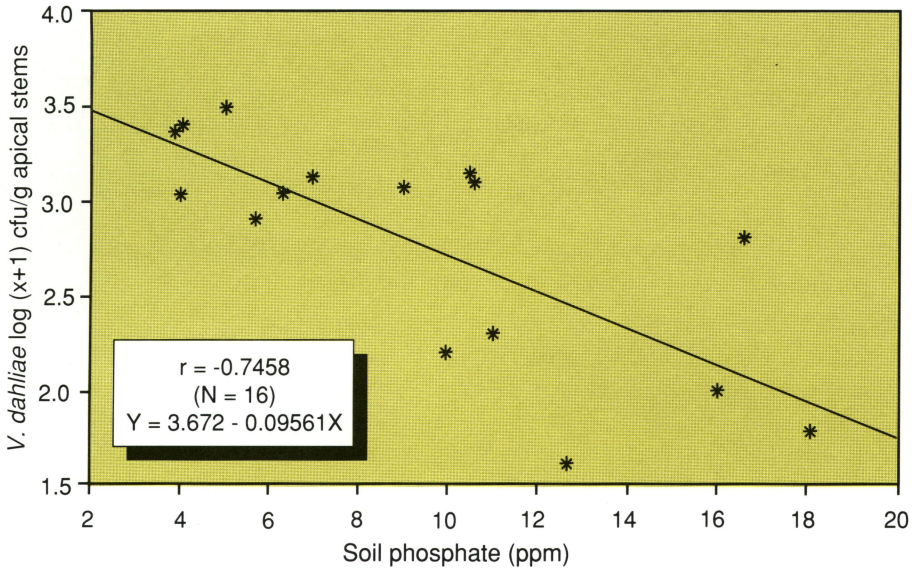


Table 2. Influence of nitrogen treatments on N availability, *V. dahliae* in stem tissue and soil, and Verticillium wilt, Egin Bench, Idaho.

Nitrogen treatment	NO_3 -N[a] from upper foot of soil	NO_3 -N[b] in petioles	*V. dahliae*[c] in soil	Verticillium wilt[d] Moderate to severe	Severe	*V. dahliae*
	(ppm)	(ppm)	(cfu/g)	(%)	(%)	(cfu/g stem tissue)
NH_4NO_3	49[e]	14,900 x[f]	45[e]	51 x[f]	26 A[g]	1,343[e, h]
Urea	31	12,400 x	37	50 x	18 A	1,447
NH_3(anhydrous)	36	21,200 y	43	25 y	9 B	773
$(NH_4)_2SO_4$	43	13,300 x	39	53 x	19 A	870

Note: All fertilizer treatments applied at 150 lb N/acre.

[a] Soil samples for analysis collected June 21 (over 1 month after fertilizer application).

[b] Petioles collected July 5, approximating time of tuberization.

[c] Soil samples taken June 21 (more than 1 month after fertilizer application) from upper 6 inches of soil profile.

[d] Wilt severity on Aug. 17.

[e] Differences not significant.

[f] Different letters denote differences to 99% probability level by Duncan's multiple range test.

[g] Different letters denote differences to 95% probability level by Duncan's multiple range test.

[h] *V. dahliae* propagule counts in potato stem tissue were positively correlated (95% probability level) with wilt severity and negatively correlated (95% probability level) with NO_3 -N in potato petioles.

Chemical Control

Consult the current edition of the *Pacific Northwest Plant Disease Control Handbook* for chemical control recommendations. A wide range of fumigants has controlled Verticillium wilt of potato, but fumigants differ in their ability to reduce populations of the soilborne pathogen *V. dahliae*.

Read the label. If the fumigant consists only

of dichloropropene (DP), do not expect a reduction of soilborne populations of the pathogen. Products consisting of only dichloropropene are effective as nematicides but not as fungicides.

For example, when dichloropropene is applied to soil at 30 gallons per acre (gal/acre), it has no direct effect against *V. dahliae* (table 3).

This same relationship appeared when field assays were made 1 year after application (table 5). Increased populations of soilborne *V. dahliae* followed treatment with dichloropropene, while decreased populations of *V. dahliae* followed mixed treatments of dichloropropene and chloropicrin. The highest yields followed treatments of dichloropropene and chloropicrin.

Soilborne inoculum

Soilborne inoculum, although of major importance, is only one of many factors related to disease severity (table 4). Several other factors (e.g., plant nutrition, irrigation, previous cropping history, presence of beneficial microflora, etc.) may have major effects upon disease severity.

At this time, we do not have the ability to accurately predict disease severity from determinations of soilborne inoculum. Use caution when basing anticipated disease severity of Verticillium wilt on soil inoculum levels.

Soil assays may vary with soil texture. For example, soil assays on coarse-textured sands generally show lower counts of *V. dahliae* than assays on soils with more clay. This does not mean that the disease will be less severe on sands than on heavier soils. In fact, the opposite may be true. Owing to a variety of physical-chemical characteristics, the presence of certain microbes, or both, some soils may suppress the pathogen. Therefore, even though inoculum levels are seemingly high, the infection process by *V. dahliae* may be inhibited and the incidence of the disease may be lower than expected.

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Table 3. Effects of fumigation on soilborne *V. dahliae* populations, Fort Hall, Idaho.

Treatment	Rate	*V. dahliae* populations
	(gal/acre)	(cfu/g)
Untreated		18 A
Dichloropropene (DP)	30	18 A
DP + 15% chloropicrin	20	6 B
DP + 15% chloropicrin	30	2 B

Note: Assays made several weeks after fumigation treatments. Different letters denote significant differences (P = .05).

Table 4. Relationships of soilborne *V. dahliae* populations to wilt incidence and yield and quality of Russet Burbank.

	Wilt	Yield (cwt/acre)			
V. dahliae	in stems Aug. 17	Total	U.S. No. 1's	Smooth tubers	Specific gravity
(cfu/g soil)	(%)		(4 to 10 ounce)	(>10 ounce)	
55 A	80 A	221 A	82 A	15 A	1.074
23 B	45 B	251 A	83 A	20 A	1.076
6 C	13 C	382 B	179 B	89 B	1.083
4 C	32 B	389 B	205 B	67 B	1.084

Note: Different letters denote significant differences (P = .05).

Table 5. Effects of fumigation on potato yield and soil populations of *V. dahliae*, Fort Hall, Idaho.

Treatment	Rate	Fumigation each year		Fumigation every other year		*V. dahliae* in soil 1 year after treatment
		Total yield	U.S. No. 1's	Total yield	U.S. No. 1's	
	(gal/acre)	(cwt/acre)				(cfu/g)
Untreated		271 X[a]	147 A[b]	279[c]	156[c]	67 BC[b]
Dichloropropene (DP)	30	301 XY	170 AB	287	155	123 A
DP + 15% chloropicrin	20	321 Y	189 B	304	174	72 BC
DP + 15% chloropicrin	30	328 Y	194 B	306	182	21 CD
DP + 30% chloropicrin	20	311 Y	179 B	306	181	21 CD
DP + 30% chloropicrin	30	317 Y	181 B	312	182	15 D

Note: Yields are mean values of 4 years' data.

[a] Different letters within column indicate significant differences (P = .01).

[b] Different letters within column indicate significant differences (P = .05).

[c] Differences not significant.

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