CULTURAL PRACTICES TO MINIMIZE YIELD LOSS FROM POTATO EARLY DYING

by
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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.

Initial symptoms of the disease in potato are a slight downward growth of petioles and yellowing of lower leaves. Leaf yellowing proceeds up the stem (often in a one-sided manner), with the upper leaves being the last to show symptoms. Leaf yellowing is then followed by wilt, browning, necrosis, flagging, and eventual death of the stem. Discoloration of conducting tissue is commonly associated with V. dahliae at the end of the season. Stem-end discoloration in tubers may also occur in severe cases - a symptom sometimes confused with net necrosis caused by the leafroll virus.

Depending on severity, time of occurrence and growing season, potato yields and tuber size may be substantially reduced. Yield losses of 50 to 100 cwt. per acre are not uncommon. Losses of up to 30 percent have been documented in southeastern Idaho.

Cropping practices may have a profound effect upon potato early dying. Table 1 and 2 show the effects of "spudded out" ground with the continuous cropping of the Russet Burbank potato for five consecutive years when compared with the weed-free fallow treatments and the continuous cropping of corn for five consecutive years. The incidence of Verticillium disease being significantly more severe as inoculum levels increased in soil. When compared with R. Burbank, the -51 potato clone is more resistant, and with this resistance the build-up of V. dahliae in soil and wilt incidence are less. Although most of the yield response is associated with the increase of V. dahliae in soil (56-66%), other factors are also contributing to the yield loss.

After several successive potato crops, the level of soilborne inoculum may be high. Table 3 illustrates the relative rate of build-up of V. dahliae in the soil with the continuous cropping of R. Burbank and -51 respectively. As shown, populations of V. dahliae in soil did not increase with the continuous cropping of R. Burbank until after four years, while five years were required for the resistant -51 clone. Our earlier investigations of 1977-1982 seem to support this relationship.

This Presentation is part of the Proceedings of the 1990 Washington State Potato Conference & Trade Fair.

SANITATION

To delay inoculum buildup, vine burning and or vine removal are recommended -- particularly on "new" potato ground. Potato stems provide the primary source of soilborne inoculum. Where local laws permit, stem burning is recommended. This practice's effectiveness depends upon complete burning of stems.

ROTATION

After several successive potato crops, the level of soilborne inoculum may be high. This inoculum is long lasting in soil. Although certain plants may produce exudates into the soil with pesticidal effects upon V. dahliae (e.g. marigold), there exist no known plants of commercial value with this capability.

Table 4 shows the respective effects of either leaving the field weed-free and fallow for five consecutive years of cropping with corn for five consecutive years. With either of these extreme treatments, the populations of V. dahliae were not reduced in soil. With grain rotations, the minimum period required to reduce inoculum effectively in moderately to heavily infested land is believed to exceed five years. In "old" potato ground, the short rotations that are commonly followed in Idaho (2 to 3 yrs) are ineffective for reducing the pathogen. The benefits derived from these rotations (improved tilth, improved soil structure, and increased organic content) are most likely not directly associated with reduced populations of V. dahliae.

Many organisms occupy the soil with the capacity to inhibit the pathogen as well as having other positive effects upon plant growth. Within Aberdeen soils, we have documented the common presence of a wide range of bacterial genera with the capability of inhibiting V. dahliae [Bacillus (10spp), Pseudomonas, Gluconobacter, Flavobacterium, and Streptomyces]. Additionally, other bacteria have also been found (e.g. Azotobacter and Azomonas sp) with the ability to fix nitrogen. The examples are many. The soil literally lives and breathes with the myriad of microbes occupying the rhizosphere (the region that surrounds the roots). It is hypothesized that the presence of these organisms may inhibit pathogens while also increasing the potential for yield. The survival of these organisms is largely dependent upon a source of food - the straw from stubble (wheat, barley, corn, etc).

I would recommend chopping this stubble between potato crops with a "chopper" or rotovater and by so doing incorporating it into the soil. When this is done, I would further recommend applying nitrogen (generally about 40 lb N/A) and following with irrigation. The additional nitrogen and moisture will hasten microbial build-up and decomposition of the straw. I believe that if you continue this practice, the productivity of your land will increase dramatically.

The cropping of grain for 2-3 years between potato crops is generally considered a minimal time period for rotation.

GREEN MANURE TREATMENTS

During 1986, an investigation involving several cropping practices was initiated. Treatments are shown in Table 5 (fallow, sugar beet, potato, wheat, sudan grass, and rape). With the exception of the potato, sugar beet and fallow treatments, all treatments involved green manure (they were disked and rotovated into the soil during mid-August and irrigated to hasten microbial breakdown). On the following year, the R. Burbank and Norgold varieties were planted over all plot sites. Results demonstrate the problem of following potato with potato. Following potato, the incidence of Verticillium was the most severe (more than twice the severity of any other treatment) and yields were the lowest (Table 6). Although not statistically significant, trends existed for substantial yield increases following the cropping with wheat, sudan grass, and rape. With the Norgold potato, the percentage of U.S. #1's was significantly lower following sugar beet when compared with either green manure treatments of wheat or sudan grass. Qualitatively, it was evident that V. dahliae microsclerotia (compact masses of V. dahliae) in soil from the green manure plots were generally compromised when compared with microsclerotia from the fallow areas (e.g. colony growth of V. dahliae from fallow areas was typically large and vigorous while colony growth from green manure plots was typically "weak").

Although this study is regarded as preliminary, our results suggest that benefits of yield and quality may be obtained following green manure treatments of either wheat, sudan grass, or rape.

Additional investigations have been initiated at Aberdeen and more information regarding the effects of green manure treatments and potato production should be available within 2-3 years.

RAPE MEAL

Field data from 2 consecutive years consistently show suppression of Verticillium wilt by as much as 89% and reduction of the root lesion nematode (Pratylenchus neglectus) by 64% when it was applied to the soil at 3 tons/acre. Unfortunately, when either of several varieties of rape were used as green manure treatments, none of these varieties showed evidence for disease suppression as observed with the meal.

The explanation for this may be related to levels of glucosinolate (active ingredient) found in rape meal compared with the levels in vegetative tissue of rape. Glucosinolate levels in the meal are high when compared with vegetative tissue.

Currently, better rape varieties with higher glucosinolate levels are being developed. (Dick Auld, U of I, PSES Dept. - personal communication).

CULTURAL MANAGEMENT

In potato fields that have been cropped for several years, the first line of defense against Verticillium wilt in Russet Burbank potatoes is optimum irrigation and soil fertility. By favoring this variety, resistance to V. dahliae is also favored.

Studies in Bingham County over several years showed that cultural management practices can have a major effect on suppressing the disease's severity. Factors related to inadequate irrigation, method or irrigation and low levels of N, P and K have been closely associated with the disease.

MOISTURE STRESS

Moisture stress increases the disease's severity. As the season progresses (particularly beyond the "flowering stage"), the influence of moisture stress on Verticillium wilt may become pronounced (Table 8).

FURROW IRRIGATION VS. SPRINKLER IRRIGATION

Verticillium wilt is usually more severe when furrow rather than sprinker irrigation is used. Water distribution problems and water stress are usually greater under furrow irrigation. This difference may also be associated with N availability. With furrow irrigation, N accumulates within the upper 3 to 6 inches of the soil profile. N is more uniformly distributed throughout the soil with sprinkler irrigation. When N is less available to the plants' root systems because of leaching and poor distribution, the disease may become more severe.

THE EFFECT OF OPTIMAL N AND P ON WILT SUPPRESSION

Field studies of 1984-1986 provided evidence that optimal N and P fertility may reduce the incidence of Verticillium wilt in the Russet Burbank potato. Significant reductions of V. dahliae colonization in potato stems occurred with increases of either N or P levels. With higher levels of P and low N, the incidence of wilt was higher - a relationship that may be explainable by an acceleration of plant maturity with high P and low N. After two seasons of continuous cropping, treatments with high levels (106 to 212 lb/A) of P were shown to produce lower populations of V. dahliae in soil compared to treatment with no added P (6 ppm of residual P in upper 30 cm of soil profile). Data serves to corroborate previous observations indicating the importance of optimal fertility for the suppression of Verticillium wilt on the Russet Burbank potato. Yields were shown to be significantly higher with the higher N and P treatments and yields with a split application of N were consistently higher than the pre-plant treatments at the same N rate.

SUMMARY OF RECOMMENDATIONS

1. If possible (particularly on new potato ground) burn vines.

2. Rotate for a minimum of 2-3 yrs with grain (e.g. wheat, barley, corn), and chop up stubble and incorporate at end of each season. To hasten the build-up of bacteria and decomposition of stubble, apply nitrogen at season end and irrigate.

3. Avoid furrow irrigation.

4. Maintain optimum irrigation practices throughout growing season of potato.

5. Maintain optimum fertility levels throughout growing season with N, P, and K. Split-apply N throughout growing season by sprinkler lines.

Table 1. Increases of wilt severity with continuous cropping of potato.

Cropping histories of preceeding 5 yrs 1983-1987	***V. dahliae* cfu/g soil 24 May**	**% Wilt Incidence 10 August**
R. Burbank	**55 A[1]**	**67.0 A[1]**
-51 potato clone	**23 B**	**29.0 C**
Corn	**6 C**	**12.0 D**
Fallow	**4 C**	**40.0 B**

[1] **Different letters denote significant differences of the .05 P level.**

Table 2. The effect of "spudded-out" ground on yield with the continuous cropping of potato.

Cropping histories of preceding 5 yrs 1983-1984	CWT/A		
	Total	U.S.#1 4-10 oz	>10 oz Smooth
R. Burbank	221 A[1]	82 A[1]	15 A[1]
-51 potato clone	251 A	83 A	20 A
Corn	382 B	179 B	89 B
Fallow	389 B	205 B	67 B

[1] Different letters denote significant differences to the .05 P level.

Table 3. Relative build-up of V. dahliae in soil with continuous cropping of potato genotypes.

Year of Crop	Cfu V. dahliae/g of soil with given clones	
	R. Burbank	A66107-51
1983	8	6
1984	11	9
1985	10	7
1986	11	0
1987	27 A	8 B[1]
1988	55 A	23 B

[1] Different letters denote differences of .05 P level (comparisons made horizontally).

Table 4. Survival of V. dahliae populations in field soil during a five-year period.

Year of Assay	Cfu V. dahliae/g of soil with given cropping treatments	
	Fallow	Corn
1983	4	7
1984	4	11
1985	13	4
1986	4	3
1987	9	5
1988	4	6

Table 5. Cropping Practices & Relationships to Verticillium Wilt Incidence -- Norgold Russet 1987.

1986 Treatments	% Severe Wilt 12 August
Fallow	8.0 BC[1]
Sugarbeet	16.4 AB
Potato	24.4 A
Wheat	10.4 BC
Sudan grass	4.4 C
Rape	8.0 BC

[1] Different letters denote differences of .05 P level.

Table 6. The Effect of Cropping Practices upon Potato Yield -- Russet Burbank.

1986 Treatments	CWT/A	
	Total	U.S. #1
Fallow	376	219 AB[1]
Sugarbeet	390	242 AB
Potato	312	173 B
Wheat	434	290 A
Sudan grass	409	277 A
Rape	410	248 AB

[1] Different letters denote significant differences to .05 P level.

Table 7. The Effect of Cropping Practices upon Potato Grade -- Norgold Russet.

1986 Treatments	% Tubers by Grade		
	U.S. #1	Malformed	Undersized
Fallow	66.5 AB[1]	7.2 BC[1]	26.3
Sugarbeet	59.8 B	10.8 AB	29.4
Potato	64.3 AB	8.9 ABC	26.8
Wheat	75.6 A	6.0 BC	18.4
Sudan grass	73.9 A	5.0 C	21.1
Rape	66.4 AB	13.6 A	20.0

[1] Different letters denote significant differences to .05 P level.

Table 8. Effect of moisture stress on Verticillium wilt in Russet Burbank potato[1].

Irrigation Treatment	% Stems with Wilt[2] August 29
No wilting point (WP)[3]	6.5 AB[5]
WP June 26-30[4]	1.5 A
WP July 21-25[4]	22.5 BC
WP Aug. 15-19[4]	43.5 C

[1] Wilt was related to presence of V. dahliae in stems.

[2] Percentage of stems showing symptoms typical of severe V. dahliae wilt (severe wilt = >75% of stem with severe wilt symptoms).

[3] Plots were maintained between 60 to 100% available soil moisture throughout season. Sprinkler irrigated.

[4] On dates indicated moisture was depleted to wilting point.

[5] Different letters denote differences to 95% probability level, and no differences between treatments with same letters.