National Verticillium Wilt Trial

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This trial is carried out annually at the Hancock Agricultural Experiment Station on a field that has been inoculated with *Verticillium dahliae*. Breeders are asked to submit selections from their breeding programs. Typically, these are advanced lines that may be released as cultivars. Information about Verticillium wilt (VW) resistance is useful when considering the merits of a line as a potential cultivar.

We have not been able to identify a single scoring strategy that effectively characterizes the resistance level of a breeding line. Consequently, we use multiple measures of resistance. First, we look at symptom expression throughout the growing season. Especially early in the season, we are able to see VW symptoms as wilting and yellowing. As the season progresses, though, it becomes increasingly difficult to distinguish between poor plant health due to VW and that due to maturity and other diseases. Another limitation of scoring symptom expression is that it does not identify symptomless carriers of the pathogen. A second scoring criterion is the number of fungal spores (conidia) in the sap of green plants. We collect green stems and squeeze a known amount of sap onto petri dishes containing a medium conducive to growth of the fungal spores. Then, after a two week incubation period, we count the number of colonies that grew. A large number of colonies indicates that the fungus was able to reproduce readily in the living plants. When the plant begins to die at the end of the growing season, the fungus moves from the vascular tissue into adjacent regions and forms resting spores (microsclerotia). So, a third measure of VW resistance is the ability of the fungus to produce these resting spores. They add to the inoculum in the soil, so it is important to identify potato varieties that do not add large numbers of microsclerotia to the soil. We collect stems from dead plants at the end of the season, dry the stems, grind them in a mill and plate the powder on petri dishes containing the selective medium. Again, we count colonies after a two week incubation period. Colony counts from dry stems are typically lower than those from sap. The two values are sometimes, but not always, correlated with each other. Our final measure of VW resistance is yield in the presence versus the absence of the pathogen. We compare yield in our VW screening field with that in an adjacent field that was fumigated before planting. Our small plot sizes (only 5 hills) limit the reliability of this measure, so we only use it for the seven cultivar standards that are in the field every year.

In 2013, the National Verticillium Wilt Trial was planted in three plots were planted on May 8. Each plot consisted of three replications of five-hill units of 60 cultivars and advanced selections from the U.S. potato breeding programs. Plot A was planted on a fumigated field and was used to evaluate yield. It included only the seven cultivar standards. Plot B was planted on a nearby field that was inoculated with *V. dahliae* in 2006 and has been maintained as a VW screening plot. This field was used to evaluate disease symptom expression, yield in the presence of *V. dahliae*, and colonization of dead (dry) stems. Plot C was also planted on the inoculated field and was destructively sampled during the summer to evaluate colonization of sap in green stems.

On July 22 and August 5 and 27, plants in Plot B were scored for percent foliage expressing Verticillium wilt symptoms. On August 5, stems from all clones in Plot C were collected, surface disinfested, and squeezed in a vice to collect sap for plating. For each plot, 100 ul of sap was plated on selective medium and the plates were incubated in the dark for two weeks. After that, they were microscopically examined to determine the number of colony forming units per 100 ul of sap. After vine kill, stems were collected from all clones in the Plot B field and allowed to air dry at room temperature. All main stems from a plot were ground in a Wiley mill and 50 mg per plot was plated on selective medium. On September 11, the seven cultivar standards in Plots A and B were harvested with a single row digger, and tubers from each plot were picked up by hand and weighed. In 2013, variability among

trial clones was high for all measures of resistance. Consequently, 2013 was a good year for distinguishing between resistant and susceptible clones.

Symptom, sap and dry stem data from the trial clones are presented in the table below. The entries were placed in two groupings, early to mid-season vine maturity and mid- to late season vine maturity. Late season clones tend to have lower symptom expression due to immature plant resistance. Symptoms were scored as the percent diseased foliage on July 22 (Vrt722), August 5 (Vrt805), and August 27 (Vrt827). The area under the disease progress curve (AUDPC) was calculated based on the three score dates. The average AUDPC of the earlier maturing clones (996) was twice as high as that of the later maturing ones (491). The number of colony forming units per 100 ul sap in green stems (sap) and per 50 mg dead dry stems (dry) was also recorded. It is common to observe differences among replications across the field, likely due in part to variability in pathogen inoculum density. An average across replications may mask these differences, so data from each replication are presented. To the left of the data set, I have indicated clones that appear to have good (*) and very good (**) resistance to VW. These clones have consistently low early season symptom expression and low stem colonization in all three replications. I tend to weight the sap scores more heavily than the others. Clones with very low sap scores in all three replications and low dry stem scores are likely the most resistant. Low symptom scores, especially during the early season, are also important. A high score, even in only one replication, likely indicates the potential to be heavily colonized by the pathogen. The best resistance among the earlier maturing clones was found in CO02024-9W (CSU), MSQ086-3 (MSU), MSS576-05SPL (MSU), W6703-5Y (UW), and W8152-1rus (UW). Among the later maturing clones, the highest levels of resistance were observed in A02424-83LB (USDA-Aberdeen), AF4573-2 (UM), MSS176-1 (MSU), and MSS487-2 (MSU). Earlier maturing clones with good apparent resistance include Accumulator (UW), AF4320-17 (UM), B3054B-24 (USDA-Beltsville), W5015-12 (UW), and later maturing ones include A02507-2LB (USDA-Aberdeen) and B2728-5 (USDA-Beltsville). The program responsible for developing and testing each clone is listed after the clone name (CSU = Colorado State University, UM = University of Maine, MSU = Michigan State University, and UW = University of Wisconsin). It is encouraging that several state and federal programs have advanced selections with potentially high levels of resistance to VW.

It is important to confirm apparent resistance with a second year of testing. Of the potentially resistant clones listed above, CO02024-9W, W8152-1rus, W5015-12, and were evaluated in 2012 and demonstrated resistance in that year as well. It is reasonable to consider these clones resistant to VW. Accumulator, W6703-5Y, AF4320-17, and A02507-2LB were also in the trial in 2012, but were more susceptible in 2012, so resistance is not as stable.

The seven cultivar checks are shown in bold face in the table. Ranger Russet is considered the most resistant check and Russet Norkotah is the most susceptible check. Colonization of stem sap in Russet Norkotah was consistently high in all three replications. Ranger Russet had surprisingly high sap counts in two replications. Dry stem counts were consistently low, though. Several advanced selections appear to have higher levels of VW resistance than the Ranger Russet.

Early to mid-season vine maturity

	Clone	Rep	Vrt722	Vrt805	Vrt827	AUDPC	Sap	Dry
	A05052-3TE (5034)	1	0	0	20	220	14	76
	A05052-3TE (5034)	2	0	0	5	55	2000	8
	A05052-3TE (5034)	3	0	0	25	275	48	0
	A99331-2Y (5005)	1	0	0	60	660	125	108
	A99331-2Y (5005)	2	0	0	50	550	160	148
	A99331-2Y (5005)	3	5	5	15	290	3000	256
*	Accumulator	1	0	15	70	1040	384	380
	Accumulator	2	10	20	60	1090	360	220
	Accumulator	3	10	10	10	360	4	3
	AF4296-3 (1219)	1	0	5	70	860	5000	352
	AF4296-3 (1219)	2	0	10	40	620	5000	2
	AF4296-3 (1219)	3	5	15	70	1075	1200	112
*	AF4320-17 (1221)	1	0	5	70	860	0	580
	AF4320-17 (1221)	2	0	10	70	950	5	2
	AF4320-17 (1221)	3	5	10	70	985	0	20
	AF4463-8 (5021)	1	0	0	40	440	0	
	AF4463-8 (5021)	2	0	5	35	475	412	
	AF4463-8 (5021)	3	0	0	25	275	3000	
	AF4532-8 (5038)	1	10	60	95	2195	4000	
	AF4532-8 (5038)	2	0	40	80	1600	4000	
	AF4532-8 (5038)	3	10	30	80	1490	5000	
	AF4614-2 (5026)	1	0	10	75	1005	400	152
	AF4614-2 (5026)	2	0	15	70	1040	4000	0
	AF4614-2 (5026)	3	0	0	70	770	580	212
	AOTX98152-3RU	1	10	30	95	1655	5000	
	AOTX98152-3RU	2	5	25	95	1530	4000	
	AOTX98152-3RU	3	10	40	90	1780	800	
	Atlantic	1	0	10	40	620	380	0
	Atlantic	2	0	10	60	840	2000	0
	Atlantic	3	0	10	60	840	8	0
	ATX91137-1RU	1	0	5	50	640	5000	0
	ATX91137-1RU	2	0	5	30	420		98
	ATX91137-1RU	3	0	0	60	660	212	212
	B2869-17 (1164)	1	5	50	95	1980	4000	
	B2869-17 (1164)	2	5	60	100	2215	5000	
	B2869-17 (1164)	3	10	60	100	2250	5000	
	B3054A-13 (7415)	1	0	5	50	640	2000	220
	B3054A-13 (7415)	2	0	20	75	1185	2000	9
	B3054A-13 (7415)	3	0	20	90	1350		0
*	B3054B-24 (2162)	1	0	10	35	565	720	0
	B3054B-24 (2162)	2	0	10	30	510	0	17
	B3054B-24 (2162)	3	5	5	30	455	0	40

	Clone	Rep	Vrt722	Vrt805	Vrt827	AUDPC	Sap	Dry
	BTX2332-1R	1	5	25	80	1365	800	44
	BTX2332-1R	2	5	5	50	675	800	4
	BTX2332-1R	3	5	10	80	1095	460	48
**	CO02024-9W	1	5	10	50	765	0	12
	CO02024-9W	2	0	10	40	620	0	0
	CO02024-9W	3	5	20	40	835	0	3
	CO02321-4W	1	0	15	80	1150	3000	80
	CO02321-4W	2	0	5	70	860	3000	52
	CO02321-4W	3	5	20	85	1330	3000	112
	CO03276-5RU	1	5	10	70	985	3000	
	CO03276-5RU	2	0	5	50	640	4000	
	CO03276-5RU	3	5	10	8	303	1720	
**	MSQ086-3	1	0	5	30	420	0	52
	MSQ086-3	2	0	0	30	330	0	0
	MSQ086-3	3	0	0	20	220	0	20
	MSR061-1	1	0	20	80	1240	640	36
	MSR061-1	2	0	10	50	730	2000	0
	MSR061-1	3	0	5	75	915	8	64
	MSS206-2	1	0	0	20	220	61	16
	MSS206-2	2	0	0	20	220	3000	0
	MSS206-2	3	0	0	40	440	660	6
**	MSS576-05SPL	1	0	5	60	750	0	0
	MSS576-05SPL	2	0	5	30	420	48	81
	MSS576-05SPL	3	10	15	60	1000	11	40
	NDTX5438-11R	1	5	35	90	1655	3000	
	NDTX5438-11R	2	5	20	80	1275	4000	
	NDTX5438-11R	3	5	40	95	1800	4000	
	Ranger Russet	1	0	0	60	660	3000	98
	Ranger Russet	2	0	0	40	440	0	35
	Ranger Russet	3	10	10	40	690	540	1
	Red Norland	1	10	30	100	1710	0	104
	Red Norland	2	15	60	100	2285	3000	11
	Red Norland	3	15	75	100	2555	2000	680
	Russet Norkotah	1	5	70	100	2395	3000	1400
	Russet Norkotah	2	10	60	100	2250	3000	3
	Russet Norkotah	3	15	60	100	2285	4000	82
	Sierra Rose	1	5	40	90	1745	0	
	Sierra Rose	2	5	40	95	1800	3000	
	Sierra Rose	3	5	30	95	1620	5000	
	Superior	1	5	50	100	2035	2000	0
	Superior	2	20	80	100	2680	3000	0
	Superior	3	10	60	100	2250	3000	52

	Clone	Rep	Vrt722	Vrt805	Vrt827	AUDPC	Sap	Dry
*	W5015-12	1	0	5	40	530	860	64
	W5015-12	2	0	0	50	550	60	11
	W5015-12	3	0	0	20	220	0	42
	W5015-5	1	0	5	30	420	3000	0
	W5015-5	2	0	0	40	440	560	9
	W5015-5	3	10	10	40	690	396	520
	W6609-3	1	5	20	60	1055	2000	
	W6609-3	2	0	0	50	550	3000	
	W6609-3	3	5	15	70	1075	72	
	W6703-1Y	1	5	15	40	745	3000	262
	W6703-1Y	2	5	20	60	1055	0	1160
	W6703-1Y	3	15	15	60	1035	312	608
**	W6703-5Y	1	0	15	40	710	0	136
	W6703-5Y	2	5	10	40	655	170	1
	W6703-5Y	3	5	5	10	235	35	12
**	W8152-1rus	1	10	15	50	890	0	4
	W8152-1rus	2	15	20	60	1125	0	115
	W8152-1rus	3	5	5	60	785	0	64
	White Pearl	1	0	10	40	620	4000	10
	White Pearl	2	0	15	70	1040	620	300
	White Pearl	3	5	15	85	1240	0	960

Mid- to late season vine maturity

	Clone	Rep	Vrt722	Vrt805	Vrt827	AUDPC	Sap	Dry
**	A02424-83LB 5023)	1	0	0	30	330	14	0
	A02424-83LB 5023)	2	0	0	35	385	50	2
	A02424-83LB 5023)	3	0	0	10	110	0	4
*	A02507-2LB	1	0	0	20	220	248	8
	A02507-2LB	2	0	0	10	110	0	0
	A02507-2LB	3	0	0	10	110	448	0
	A03921-2 (5030)	1	0	25	60	1110	2000	28
	A03921-2 (5030)	2	0	20	50	910	4000	10
	A03921-2 (5030)	3	10	25	75	1345	408	28
	AC03433-1W	1	0	0	20	220	1200	48
	AC03433-1W	2	0	0	15	165	208	1
	AC03433-1W	3	0	0	40	440	248	0
	AF4320-7 (1220)	1	0	0	30	330	0	48
	AF4320-7 (1220)	2	0	5	40	530	2000	720
	AF4320-7 (1220)	3	0	0	0	0	0	56
	AF4342-3 (1223)	1	0	0	15	165	5000	
	AF4342-3 (1223)	2	0	0	40	440	3000	
	AF4342-3 (1223)	3	0	0	25	275	3000	

	Clone	Rep	Vrt722	Vrt805	Vrt827	AUDPC	Sap	Dry
**	AF4573-2 (5025)	1	0	30	60	1200	48	8
	AF4573-2 (5025)	2	0	0	25	275	70	12
	AF4573-2 (5025)	3	0	0	60	660		20
*	B2728-5 (1290)	1	0	0	20	220	640	112
	B2728-5 (1290)	2	0	0	25	275	6	0
	B2728-5 (1290)	3	0	0	5	55	0	0
	BNC244-10 (1263)	1	0	0	80	880	4000	
	BNC244-10 (1263)	2	0	20	70	1130	4000	6
	BNC244-10 (1263)	3	0	0	70	770	5000	
**	MSS176-1	1	0	0	5	55	0	68
	MSS176-1	2	0	0	10	110	0	0
	MSS176-1	3	0	0	10	110	20	4
**	MSS487-2	1	0	10	30	510	0	122
	MSS487-2	2	0	0	10	110	52	17
	MSS487-2	3	0	0	15	165	110	15
	Russet Burbank	1	5	20	95	1440	2000	3
	Russet Burbank	2	0	10	80	1060	225	13
	Russet Burbank	3	5	25	90	1475	3000	10