

New Sources of Resistance to Eastern Filbert Blight in Hazelnut

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ABSTRACT

Eastern filbert blight (EFB), caused by the pyrenomycete *Anisogramma anomala*, is a serious threat to the hazelnut industry in the Pacific Northwest. The fungus is endemic in the eastern United States where it occasionally produces small cankers on the wild American hazelnut (*C. americana*). In contrast, most cultivars of the commercially important European hazelnut (*C. avellana*) are susceptible. Recommended cultural practices including scouting, pruning out infected branches, and fungicide applications slow disease spread but are expensive. Genetic resistance is the most promising control method. Recent OSU releases carry a dominant allele for resistance from 'Gasaway'. However, 'Gasaway' and some of its offspring have been infected by isolates from New Jersey, Minnesota, and Michigan. There is an urgent need to find and study new sources of resistance. We investigated 12 new sources of EFB resistance: 'Grand Traverse', *C. heterophylla* 'Ogyoo', 'Yoder #5', *C. americana* 'Rush', 'Uebov' and seven selections from a Forestry Institute in Moscow, Russia. Seedling populations segregating for resistance were inoculated by either exposure of potted trees under a structure topped with diseased branches or greenhouse inoculation. DNA extracted from these seedlings was amplified with primers for microsatellite markers on linkage group 6 (LG6). For structure inoculated progenies, resistance from 'Grand Traverse' and *C. heterophylla* 'Ogyoo' was assigned to LG6, resistance from 'Yoder #5' was assigned to LG7 while 'Rush' was linked to markers from both LG2 and LG7. Similarly, greenhouse inoculated 'Uebov' progenies were mapped to LG6. Seven Moscow selections that remained free of EFB following greenhouse inoculation were crossed with susceptible parents and ~60 seedlings of each progeny were inoculated in the greenhouse. Very few seedlings of Moscow selections N01, N01-06, and N01-07 remained free of disease and were likely escapes. In contrast, seedlings of Moscow selections N23, N26, N27 and Moscow N37 segregated in a 1:1 ratio, indicating control by a single locus and a dominant allele for resistance. Resistance from Moscow N27 appears to be on LG2, while resistance from N23, N27 and N37 were not significantly correlated with any of LG6, LG2 and LG7 alleles. These three Moscow sources are unique sources of EFB resistance. Resistance from these new sources will be mapped, and linked markers developed and used in pyramiding different resistance genes for durable EFB resistance.

INTRODUCTION

Commercial cultivation of European hazelnuts (*Corylus avellana* L.) in Willamette valley is threatened by fungal disease eastern filbert blight (EFB) caused by the pyrenomycete *Anisogramma anomala* (Peck) E. Müller. 'Gasaway' was found to be resistant to EFB and the resistance mechanism study identified a single locus with a dominant allele for resistance. 'Gasaway' have been extensively used in OSU breeding program and several recent releases carry a dominant allele for resistance from 'Gasaway'. However, 'Gasaway' and some of its offspring have been infected by *A. anomala* isolates indicating urgent need to investigate new sources of resistance and incorporate these new resistance sources into the upcoming releases. Identification, studying, and mapping of new resistant selection are continuing with the concern of possible breakdown of using single dominant resistance gene. 12 new EFB resistance sources are investigated by inoculating segregating progenies under inoculation structure, green house and field tying method.

MATERIALS AND METHODS

- Progenies segregating for resistance from four sources ('Grand Traverse', *C. heterophylla* 'Ogyoo', 'Yoder #5', and *C. americana* 'Rush') were exposed to EFB under a structure topped with diseased wood.
- Seedlings representing seven Moscow selections (N01, N01-06, N01-07, N23, N26, N27, and N37) were inoculated in the greenhouse.
- 3 scions for each seedlings of 'Uebov' progenies (07024, 08035) were grafted and inoculated in the greenhouse.

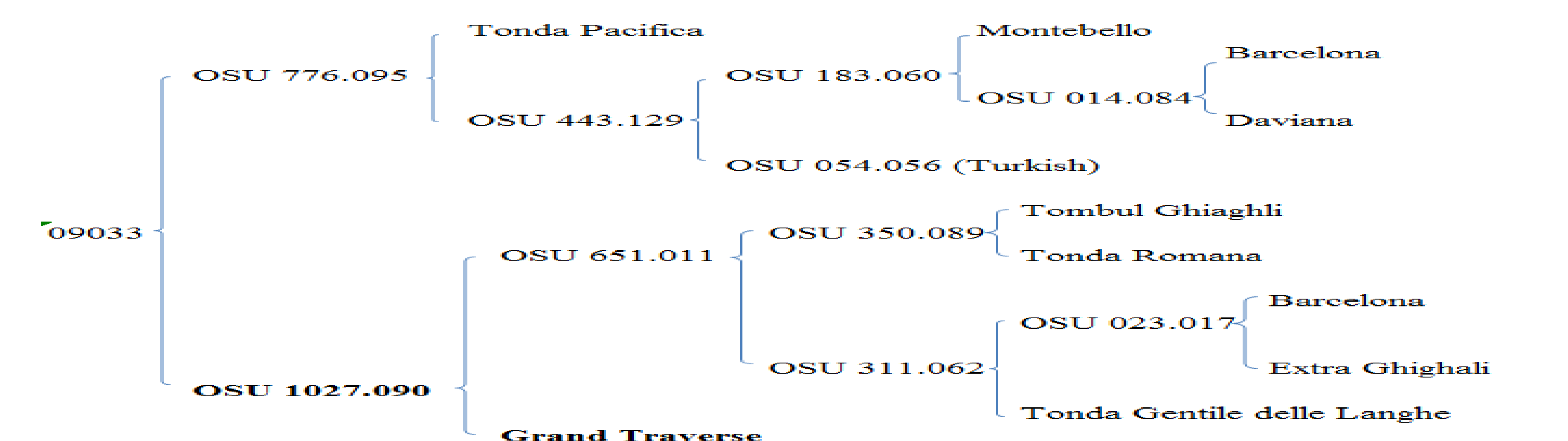


Fig 1: Pedigree of hazelnut progeny 09033 and 07024 segregating for 'Grand Traverse' and 'Uebov' resistance respectively

Table 1: Linkage group assignment of hazelnut progenies segregating for EFB resistance

Progeny	Resistance Source	Linkage group assignment	Source of resistance
12028	OSU 1266.005 x Moscow N23	NOT on LG6, LG7, LG2	Moscow
12029	OSU 919.031 x Moscow N26	NOT on LG6, LG7, LG2	Moscow
12030	OSU 1269.020 x Moscow N27	LG2	Moscow
12031	Moscow N37 x OSU 919.031	NOT on LG6, LG7, LG2	Moscow
07024	OSU 741.105 x Uebov	LG6	Uebov
09033	OSU 776.095 x OSU 1027.090	LG6	Grand Traverse
09034	OSU 1181.023 x OSU 1029.039	LG6	<i>C. heterophylla</i> 'Ogyoo'
09035	OSU 1181.023 x OSU 1053.089	LG6	<i>C. heterophylla</i> 'Ogyoo'
09036	OSU 776.095 x OSU 1049.030	LG7	Yoder #5
09037	OSU 1086.053 x OSU 1031.015	both on LG-7 and LG-2	<i>C. americana</i> 'Rush'
09038	OSU 1086.053 x OSU 1053.089	both on LG-7 and LG-2	<i>C. americana</i> 'Rush'
08035	OSU 1038.008 x OSU 978.058	LG7	Yoder #5

REFERENCES
 Colburn, B. C., Mehlenbacher, S. A., Sathuvalli, V. R. and Smith, D. C. 2015. Eastern Filbert Blight Resistance in Hazelnut Accessions 'Culplà', 'Crvenje', and OSU 495.072. J. Amer. Soc. Hort. Sci. 140(2): 191-200.
 Sathuvalli, V.R., Chen H., Mehlenbacher S.A. and Smith, D.C. 2011. DNA markers linked to eastern filbert blight resistance in 'Ratoli' hazelnut (*Corylus avellana* L.). Tree Genetics and Genomes 7:337-345.

Fig. 1: Disease response and segregation for EFB resistance in hazelnut

Progeny	Parents	No. of trees		Expected	χ^2	P	Inoculation	
		Resistant	Susceptible					
08035	OSU 1038.008 x OSU 978.058	62	47	1:1	2.06	0.15	Disease branch tying	
09033	OSU 776.095 x OSU 1027.090	22	37	1:1	3.81	0.05	Structure	
09036	OSU 776.095 x OSU 1049.030	46	32	1:1	2.51	0.11	Structure	
09034	OSU 1181.023 x OSU 1029.039	10	6	1:1	1	0.32	Structure	
09035	OSU 1181.023 x OSU 1053.089	8	8	1:1	0	1		
Pooled data		18	14	1:1	0.5	0.48		
Heterogeneity χ^2 (d.f.=1)								
09037	OSU 1086.053 x OSU 1031.015	53	46	1:1	0.49	0.48	Structure	
09038	OSU 1086.053 x OSU 1053.08	38	28	1:1	1.52	0.22		
Pooled data		91	74	1:1	1.75	0.19		
Heterogeneity χ^2 (degree of freedom=1)								
12025	OSU 1269.020 x Moscow N01	9	49	1:1	27.59	<0.001	Greenhouse seedlings	
12025	OSU 1269.020 x Moscow N01	9	49	1:3	2.78	0.1		
12026	OSU 1235.119 x Moscow N01-06	4	51	1:1	40.16	<0.001		
12026	OSU 1235.119 x Moscow N01-06	4	51	1:3	9.22	0.002		
12027	OSU 1266.005 x Moscow N01-07	6	55	1:1	39.36	<0.000		
12027	OSU 1266.005 x Moscow N01-07	6	55	1:3	7.48	0.006		
12028	OSU 1266.005 x Moscow N23	32	25	1:1	0.86	0.35		
12029	OSU 919.031 x Moscow N26	37	20	1:1	5.07	0.84		
12030	OSU 1269.020 x Moscow N27	32	26	1:1	0.62	0.43		
12031	Moscow N37 x OSU 919.031	28	35	1:1	0.78	0.38		
06030	OSU 675.028 x Uebov	13	69	1:1	38.24	<0.000		Greenhouse grafted
06030	OSU 675.028 x Uebov	13	69	1:3	3.66	0.06		
07024	OSU 741.105 x Uebov	12	73	1:1	43.78	<0.000		
07024	OSU 741.105 x Uebov	12	73	1:3	5.37	0.02		
Pooled (1:1)		25	142	1:1	81.97	<0.000		
Pooled (1:3)		25	142	1:3	8.96	0.002		
Heterogeneity χ^2 (d.f.=1)								

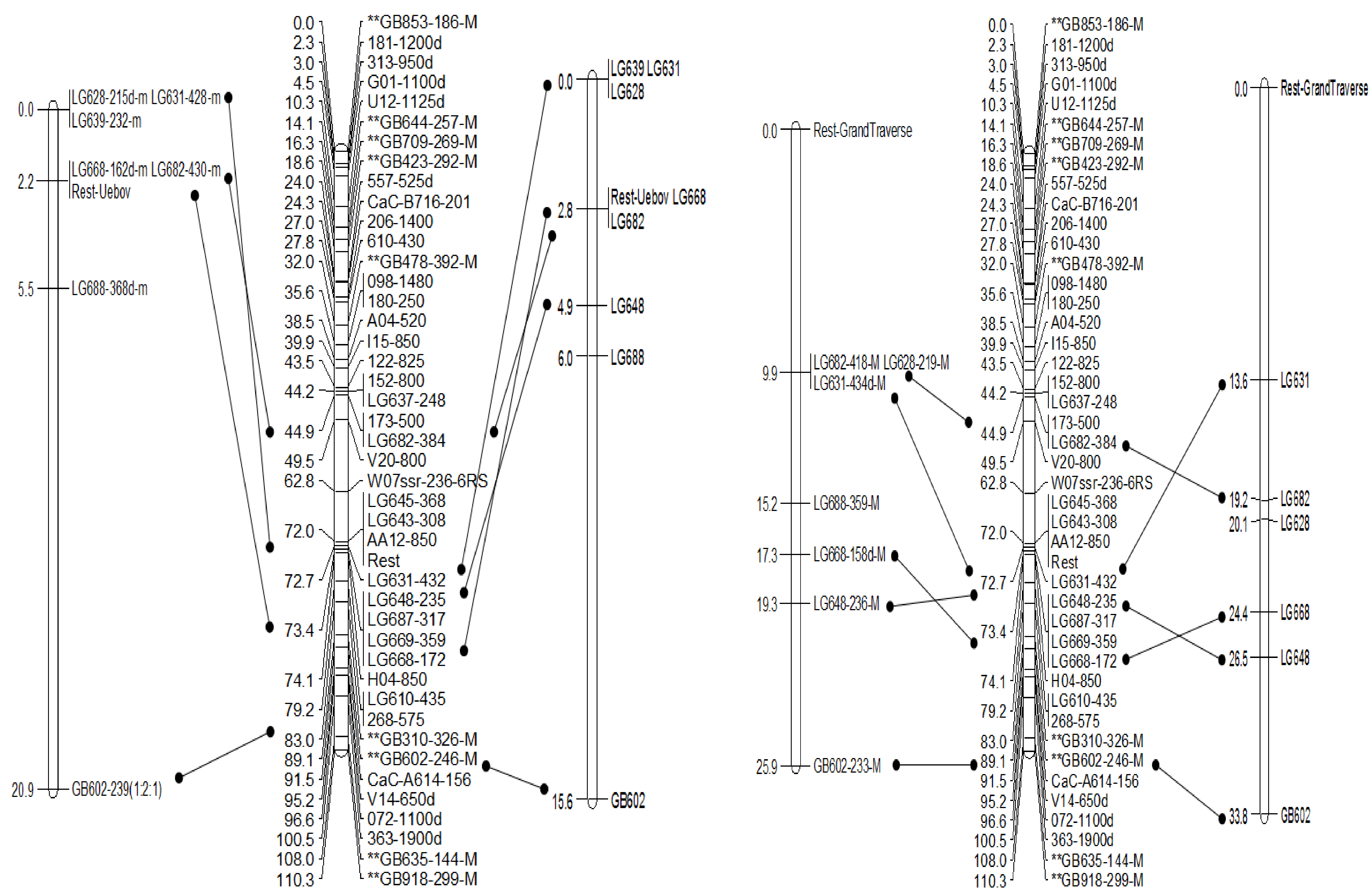


Fig 2: Map of LG 6 in 'Uebov' progenies 07024 and 'Grand Traverse' progeny 09033. Maps are produced for resistant male parent (RP), integrated map (CP) for both parents of a cross., and compared with reference map (OSU 252.146 x OSU 414.062) segregating for 'Gasaway' resistance.

RESULTS AND DISCUSSION

For all resistance sources studied, resistant parents did not show any symptoms of disease while the susceptible parents developed cankers. Very few seedlings of Moscow selections N01, N01-06, and N01-07 were resistant and were likely escapes. 'Grand Traverse', *C. heterophylla* 'Ogyoo', 'Yoder #5', *C. americana* 'Rush', Moscow N23, N26, N27, and N37 segregated in 1:1 ratio, indicating resistance governed by a single locus and a dominant allele for resistance. While 'Uebov' segregating in 3:1 ratio is likely due to 2 heterozygous loci involved in resistance expression and susceptible are recessive at both loci. Resistance for 'Uebov' and 'Grand Traverse' are mapped to LG6. Similarly, 'Yoder #5' is assigned to LG7, 'Moscow N27' to LG2, while '*C. americana* 'Rush' is linked to markers from both LG2 and LG7. Resistance from other Moscow selections N23, N26, and N37 did not co-segregate with either of LG6, LG7, and LG2 markers, and has not been assigned to LGs, but seems to be completely new resistance sources at different LGs.