

A REPORT TO THE CALIFORNIA TREE FRUIT AGREEMENT

Title: A greater number of rootstock choices can provide a partial alternative to methyl bromide fumigation.

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Overview:

From 2004 to 2008 we developed a nematode rootstock profile for roughly forty different *Prunus* rootstocks having the potential of becoming an alternative to Nemaguard rootstock. In conducting these studies we became aware that there may be as many as 80 *Prunus* rootstocks available across the globe. Some of these are not very different from those in our studies while others may be ones we have already screened but under a different name. In general we believe we have developed the nematode host status for the bulk of *Prunus* rootstocks currently available. Our studies received funding from CTFA and California Almond Board; the latter group being more interested in stocks imparting vigor greater than that of Nemaguard. An important bias in our study was to make sure we also searched among rootstocks having parentage quite different from that of Nemaguard. Although some of these studies were originally planned to be 6-month studies we quickly learned that our best answers were coming from studies that lasted two years as populations we thought were not resistant actually finally showed their resistance and vice versa. For ring nematode we planned on a 2-year study but we are now aware of a short-coming when evaluating Viking, Atlas and Hansen 536 rootstocks so half of the ring nematode tests will be continued into a third-year.

Three fourths of the rootstocks were resistant to root-knot nematode, an aggressive population of *Meloidogyne incognita*. There are other species and races of root-knot nematode but the population we chose did exhibit abundant virulence as it enabled the separation of Guardian from Nemaguard as well as a few other surprises. The thirty-one rootstocks with resistance to root-knot oftentimes had Nemaguard within their parentage, but not always. Other sources of resistance included Okinawa parentage and in one case the parentage also included Harrow Blood (HBOK). Hiawatha is also known for its root-knot resistance.

Only a single grouping of rootstocks provided resistance to *Pratylenchus vulnus*, root-lesion nematode. These stocks are named Krymsk 1 and Krymsk 2 and originate from the Black Sea area of the Ukraine. These two stocks contain *Prunus tomentosa* as one of the parents and this source we reported many years ago to possess resistance to this nematode. During these studies we learned that this cross of *P. tomentosa* and *P. cerasiferae* also provides tolerance to feeding by root-lesion and root-knot nematodes. We can also report there is moderate tolerance to root-lesion within Garnem rootstock however this rootstock is highly susceptible to ring nematode and therefore Bacterial Canker Complex. All the other rootstocks were susceptible to *P. vulnus* but several of

the stocks were significantly more susceptible than Nemaguard so there are some rootstocks that should be avoided.

We did not find a single rootstock that could be referred to as resistant to ring nematode, *Criconemoides xenoplax*. Viking and Atlas came the closest to being called resistant but only when they had been in a commercial setting for at least three years. Lovell supports approximately 40% of the ring nematode population of Nemaguard, Guardian approximately 60% of that of Nemaguard. In three replicated field tests monitored at 3 to 7 years after planting the ring nematode populations on Viking did not exceed 15% of that found on Nemaguard. As previously experienced with grape rootstocks, there must be fewer than 5% of the own-rooted population level for us to refer to a rootstock as resistant to ring nematode.

The *Prunus*/nematode profiles that we have developed from these studies have major value as an indicator of which rootstocks not to choose when searching for an alternative to Nemaguard. In the results section we indicate a short list of rootstocks having value as long as their limitations are also taken into account.

Objectives:

- 1) In greenhouse or small plot settings determine first year growth rate of Nemaguard compared to eight alternative rootstocks in the presence of replant soil with or without nematodes compared to fumigated soil.
- 2) Determine first and second year growth rate of eight alternative rootstocks in various field settings previously planted to Nemaguard or Marianna Plum.
- 3) Interact with farm advisors, extension specialists, or the Protected Harvest group to insert field diagnosis, use of new rootstocks, Roundup treatments, and other strategies into the overall replanting process where MB and Telone II will not be used.

Procedures:

Obj. 1. In 2005 we installed in randomized complete blocks six replicates of six rootstocks, irrigated by drip for one full season. This was a small plot study. The rootstocks included Marianna 2624, Nemaguard, Viking, two sets of Torinel, Emphyrean 2, and Atlas. We then harvested entire trees and their roots to determine tree biomass and nematode development.

Obj. 2. Trees to be planted include some that are ½ or ¼ Nemaguard parentage and a few with no Nemaguard parentage (Krymsk 1 and Flordaguard). They will be planted into a field with *P. vulnus* nematode and *M. incognita* nematodes present. Trees will be planted on 8-foot spacings down the row with 15 feet between rows. In spring 2006 trees will be budded to a common plum or peach scion. The planting site consists of one row treated with Telone II adjacent to an untreated row with eight reps of each. Tree growth will be monitored along with nematode development. Selections include: Nemaguard, Emphyrean 2, Monegro, Torinel, Viking, Krymsk 1, open space, Marianna 2624, Krymsk 8, Flordaguard, Garnem, and Cadaman. One of our goals is to eventually monitor yield and fruit size from these trees.

Obj. 3. Interactions with personnel from the Protected Harvest group have been meager. This PI is submitting for a large grant to study the entire process of replanting without methyl bromide or Telone. If that grant is funded the work will be in grower settings and with the assistance of interested farm advisors.

Results and Discussion:

Our nematode/Prunus rootstock profiles can be summarized into three charts where host status of the various rootstocks is compared to that of Nemaguard. The affinity of root-knot nematode, *Meloidogyne incognita*, for the various rootstocks is listed in Chart 1. Notice the lengthy list of rootstocks available for root-knot nematode resistance.

The affinity of root-lesion nematode, *Pratylenchus vulnus*, for the various rootstocks is listed in Chart 2. Notice the only source of resistance is Krymsk 1 and its parentage is *Prunus tomentosa*. Garnem, Bright's Hybrid and Hansen 536 exhibit moderate resistance. The remaining rootstocks are all susceptible to root-lesion nematode but there are some that are likely poorer hosts than others with Nemaguard approximately in the middle of the list.

The affinity of ring nematode, *Criconemoides xenoplax*, for the various rootstocks is listed in Chart 3. It was the development of this latter chart where we encountered greatest difficulties when comparing our two-year data sets with data that came from farm advisor trials in commercial field settings. Notice that we conducted tests on Viking in 04-05 and then repeated them in 06-07 only to find the same result but both these results are different from 3-year field tests. We will continue this trial for one more year before we publish any of our rootstock profiles. It appears that 2 years of evaluation against ring nematode is not as accurate as 3-year evaluations. Field evaluations indicate our data for Atlas, Viking and Hansen 536 are inaccurate and we do not currently have an explanation for this discrepancy.

In spring 2007 John Slaughter of Burchell Nursery assisted us with grafting of various scions onto various rootstocks. Our particular interest was scion compatibilities of Krymsk 1 and Flordaguard but he also grafted eight other rootstocks in which we still have interest. In Table 4 we have indicated the compatibility of Krymsk 1 for a dozen scions. It appears that these 12 scions have affinity for Krymsk 1 in the first year but with all the suckering we are seeing we anticipate perhaps some problems ahead. Meanwhile, we do have four-year old Krymsk 1 with nonpareil almond as a scion and it has never suckered. Perhaps Krymsk 1 needs to be disbudded at grafting time.

Roger Duncan, the farm advisor in Stanislaus Co, is conducting a field trial with a number of rootstocks that were not available when we first began this four-year study. We sampled that site in 2005 and will do so again in 2007-08, see Table 5. We believe data from his research site are providing useful answers about ring nematode but also he has one HBOK rootstock under evaluation that is performing as well as Viking. Viking always starts out better in fumigated soil but Okinawa parentage may provide tolerance to the rejection component of the replant problem. It does in Hansen 536. Apparently HBOK-1 is also slightly reduced in vigor when compared to Nemaguard.

Rootstocks of future interest to stone fruit growers

Viking Rootstock

Bare root trees of Viking rootstock [(plum x almond) X Nemaguard] have always grown best for us when planted to fumigated soil compared to non-fumigated. This has occurred whether they were planted to soil with nematodes but no replant problem; or when planted to the replant problem alone. The nursery has long indicated that roots of Viking should not be allowed to dry out just prior to planting but from our studies young roots of Viking are susceptible to many types of root feeding or obvious damage that might occur in their first leaf or just prior to planting. Strip fumigation will benefit the first-year growth of these trees and in the second year any poor growth can usually be overcome. This rootstock needs to be on the top of the rootstock list for any stone fruit replanting that occurs in sandy or loamy sand soils where ring nematode is known to occur. In many of these sandy soils there is also present the root-lesion nematode. Viking is a slightly better host for root-lesion than Nemaguard. It appears to be equal to Nemaguard in its resistance to root-knot nematodes. Viking exhibits affinity to all the same scions as Nemaguard.

Hansen 536 Rootstock

This hybrid of Titan almond x Okinawa peach can impart 20 % more vigor than Nemaguard. Those growers not wishing to fumigate can achieve excellent first-year stands by treating the previous Nemaguard orchard with Roundup and waiting a full year. Hansen 536 is of parentage that provides tolerance to the rejection component of the replant problem. It displays adequate resistance to root knot nematode when following Nemaguard. It displays resistance to root-lesion nematode that is somewhat better than that of Nemaguard. However, its downfall is that it is a superior host of ring nematode so it should not be planted into soils having high water infiltration capability, primarily sands or well structured clay loam soils. This is a rootstock suited to fine sandy loam or silty textured soils where plenty of vigor is not a problem.

HBOK rootstocks

We have not evaluated this grouping of stocks as thoroughly as others discussed here. One selection, HBOK-10, was as resistant to root-knot as Nemaguard but supported half the number of root-lesion as Nemaguard. Another selection HBOK-50 supported five-fold the population of root-lesion that Nemaguard supported while providing root-knot nematode resistance. Then, in a 3-year-old field trial of Roger Duncan it was apparent HBOK-1 showed ring nematode protection greater than that of Lovell and similar to that of Viking among the replicated rootstocks. This grouping of selections needs greater investigation because Okinawa parentage could likely provide greater tolerance to the rejection component of the replant problem.

Krymsk 1

This is the only rootstock we have identified to provide resistance to root-lesion nematode. It is dwarfing by as much as 50% of that of Nemaguard. It hosts ring

nematode at about the same level as Nemaguard so avoidance of sandy soils would be important. It has a resistance mechanism to root-knot nematodes within root tissues older than 60 days but at its root tips it is susceptible to root-knot. Lovell, for example, is root-knot susceptible even within tissues that are five years old. Krymsk 1 rootstock has peculiar grafting affinities and the scions may not fully express incompatibility in their first year. It also suckers, thus there is need to obtain nursery stock that has been disbudded below the graft union.

Guardian

This rootstock is an offspring of the 1937 Stribling 37 rootstock. It does support some populations of root-knot nematode, *M. incognita*, but like Krymsk 1 can limit nematode infection to its youngest roots. It is preferred for the protection it offers against ring nematode but our evaluations indicate that protection is not quite as good as that offered by Lovell. Against the root-lesion nematode it has performed similar to Nemaguard. This rootstock offers vigor similar to Nemaguard and will be useful in Bacterial Canker sites that have received a good pre-plant fumigation.

Future Experimentation

Based on the above rootstock information we now have at least two rootstocks worthy of field evaluation in settings where pre-plant fumigation is not planned. These include Krymsk 1, particularly in sites where root-lesion nematode is prevalent and HBOK, particularly HBOK-1 in sites where ring nematode is prevalent. In ring nematode sites where strip fumigation is permissible it is Viking and Guardian rootstocks that should be considered. Wherever there is an 8 to 10 foot wide strip application the rejection component is adequately controlled but nematodes are missed beyond that zone. Where trees are to be replanted without fumigation we will be treating the previous Nemaguard trees with Roundup, waiting a full year and then replanting on one of these two rootstocks that looks promising.

Table 1. Ranking of *Prunus* rootstocks against *M. incognita*

A 2-year study
nematodes/gr root

<i>Pistacia atlantica</i>	0
Nemaguard	0
Garnem	0
Bright's Hybrid-4	0
Julior	0
Bright's Hybrid-1	0
Hansen 536	0
Flordaguard	0
Torinel	0
Empyrean 2	0
Hiawatha	0
Cornerstone	0
Viking	0
Empyrean 1	0
Okinawa	0
Cadaman	0
Pumiselect	0
Ishtara	0
Monegro	0
Atlas	0
Nickels	0
Flor x Alnem	0
Krymsk 8	0
RedGlow	0
Citation	0
MRS 2-8	0
HBOK 50	0
Flor x weep peach	0
Bright's Hybrid-5	0
HBOK-10	0.08
Empyrean 101	0.29
Empyrean 3	0.91
Controller 9	11.6
Guardian	12.1
Krymsk 1	15.9
Paramount	17
Lovell	31
Krymsk 2	31.4
Controller 5	42.9
Krymsk 86	51.6

P=0.05

Table 2. Ranking of *Prunus* rootstocks against *P. vulnus*

	A 2-year study	as % of	Soil counts reported as a % of those on Nemaguard		
	nematodes/gr root	Nemaguard	2-year trial		
				3-year field trial	7-year field trial
Krymsk 2	0.03		0.40%		
Krymsk 1	0.17		2.4		
<i>Pistacia atlantica</i>	0.2		2.8		
Garnem	0.3		4.2		
Bright's Hybrid -4	0.5		7		
Bright's Hybrid -5	0.6		8.4		
Hansen 536	0.61		8.6	22	187
Bright's Hybrid-1	0.63		8.9		189
Paramount	1.2		16.9		
Controller 9	1.6		22.5		
Flordaguard	1.6		22.5		
HBOK-10	3.3		46		
Empyrean 2	5		70.4	294	
Torinel	5.3		75		
Guardian	6.2		87.3	111	138
Hiawatha	6.8		96		
Nemaguard	7.1		100	(actual # 1.8) 100	(actual # 305) 100
Lovell	7.4		104	411	247
Cornerstone	8.5				
Viking	8.9			211	100
Empyrean 1	9			1133	
Okinawa	9.7				
Cadaman	10.8			1344	
Krymsk 86	11				
Pumiselect	11.7				
Ishtara	13.7				
Citation	17.4				
Monegro	17.7				
Atlas	23.9			1177	204
Nickels	26.3			22	183
Flor x Alnem	27.2				
Krymsk 8	28.9				
Redglow	32.3				
MRS 2-8	37.7				
HBOK-50	39				
Flor x Weep peach	40				
Controller 5	51.6				
Empyrean 101	57.6				
Julior	71.4			38,611	
Empyrean 3	72.8				

P=0.05

Table 3. Ranking of *Prunus* rootstocks against *Criconemoides xenoplax*

	2-yr soil counts expressed as a % of Nemaguard	Values reported as a % of that on Nemaguard			
		3-yr field trial	7-yr field trial	7-yr field trial	
Lovell 04-05	48		1	26	
Lovell 06-07	34				
Flordaguard	40				
Hiawatha	56				
UCB1 Pistachio	58				
Guardian	61	111		44	
Pumiselect	63				
Bright's Hybrid -1	67			153	147
Bright's Hybrid-5	68				
Torinel	71				
Hansen 536	73	7300		119	430
E54-043	75				
Viking 06-07	78				
Krymsk 1	94				
Viking 04-05	95	0		13	0
Cadaman	96	94			
Nemaguard 04-07	100	(38.1) 100	(423) 100	(375) 100	
Del Rey Plum	108				
MRS 2-8	109				
Marianna 2624	113				
Empyrean 1	117	13			
Cornerstone	117	6200			
D63-182	118				
Nickels	119	578		104	159
Krymsk 86	121				
E54-043	130				
Monegro	140				
Ishtara	148				
Garnem	193				
Atlas	234	0		95	9
Empyrean 2	323	92			
Julior	406	4870			

Table 4. First-year grafting affinity of Krymsk 1 rootstock for various scions

	% take	% trees w/ sprouts
Spring Flare Nectarine	100	100
Spring Flame Peach	100	100
J40.111 Peach	66	100
July Flame Peach	100	100
Glacier White Peach	100	100
Black Splendor Plum	83	100
Owen Tanner Plum	100	60
Tulare Giant Prune	100	100
French Prune	100	80
Castlebrite Apricot	100	80
Padre Almond	100	83
Nonpareil Almond	100	80

Table 5. Field trial data from Roger Duncan field trial, Stanislaus Co.

	<u>ring nema</u>	<u>root lesion</u>	<u>root knot</u>
Rootstock			
Nickles	1705	24	11
K119-50	1348	5.8	165
Hansen 536	1239	148	0.2
Hiawatha	937	35	4.4
<i>Prunus subhirtella</i>	895	11	426
Controller 9	860	38	125
Nemaguard	676	218	1
Controller 5	656	82	161
Flordaguard	587	107	0.2
Cadaman	521	3.7	0
St Anthony	463	27	50
HBOK-32	413	108	5.3
Atlas	281	106	18
Guardian	275	2.8	66
<i>Prunus mira</i>	273	5	0
Compass	249	172	4.5
Lovell	215	101	12.4
HBOK-15	171	434	0
Viking	163	14	1
HBOK-1	163	61	0
<i>Prunus ferganensis</i>	66	3.8	153
HBOK-17(1 rep only)	6	0	56