95-CJ3

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Third-Year Progress Report to Various California Tree and Vine Commodity Groups

by
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April 1, 1996

Tree and vine commodity groups including the California Almond Board have committed a total of $50,000/year for each of the last three years to aid our search for replacements for soil fumigants. With these grower funds I had planned to garner another $150,000/year of state or federal monies to run a fast-paced field research effort. The lack of public funding forced us to downsize our experiments in January 1995. That trend continues. This report will summarize our three years' of findings and give direction to new trials should funding become available. This report is being written prior to obtaining the second-year nematode and growth data from plots at Kearney Ag Center.

Telone

In October 1995 this product received reregistration for tree and vine growers at 35 gallons/acre. Use will be restricted in a variety of ways but treatments appear workable. At 35 gallons per acre applied to dried soil with some surface moisture one can expect kill of remnant roots 4-5 feet deep and 99.9% nematode kill throughout the surface 5 feet of soil. For growers, this is the best news in this report.

Telone EC Drench

Although the emulsified product is not registered in the United States for tree and vine crops, we have obtained two years of nematode and plant growth data showing the drench treatment to perform comparable to that of methyl bromide or shanked Telone. Using a drench we have the potential to reduce 1,3-D volatilization from the field as compared to shanked Telone. The attached report (Addendum 1) explains in further detail.

MIT Liberators Drench

We have had success with Vapam (see addendum 2). Of course, other people have before but without consistency. We believe our success is repeatable because it has grown out of an improved understanding of the deficiencies associated with MIT. Our procedure is to treat soon after plant removal at 200 gallons/acre broadcast in 6 inches water. We believe this can be done by basin irrigation or even sprinklers, but the 6 inches must be infiltrated within 8 hours and every drop of water needs to contain the Vapam. Then, wait 12 to 18 months before replanting. We grew nonhost rotation crops during this waiting time. Then, at planting time place a full macro and micro nutrient fertilizer at the planting site or soon thereafter. Growers having soil that will infiltrate 6 inches water in 4 hours or less and are trying to control ectoparasitic nematodes may be successful at treatment rates closer to 100 gallons/acre. Growers having sand streaks in the area from Merced to Escalon are candidates for the lower rates. Current registration for Vapam limits treatments to 100 gallons/acre. The above procedure takes into account the mediocre ability of MIT to penetrate a root, the existence of a biological vacuum after treatment, and the occurrence of poor growth following higher treatment rates. See Addenda 2 and 3 for more information.

<u>Acrolein Drench</u>

This product has the potential to be a useful drench. It has current registrations as an herbicide for aquatic weeds and for kill of squirrels. Present technologies for delivery into the soil are its major limitation. It apparently kills old tree roots and nematodes within. Walnuts grew especially well after a drenching. Our interest in Acrolein is dependent on new delivery methods.

<u>Urea Drench</u>

At 300 pounds nitrogen/acre in 6 inches water, Urea is lethal to 95% of the nematodes in the surface 5 feet of soil. Unfortunately, it does not kill old tree roots or penetrate them so endoparasitic nematodes escape the treatment. Urea may also have some impact against the replant problem. This treatment needs field evaluation where ring nematode is the major problem.

<u>Anaerobic Conditions</u>

We have evaluated two procedures for creating anaerobic conditions in the surface 5 feet of soil. The use of 40 days and nights of flooding in December-January did not kill old roots or nematodes. Replanting 6 weeks after such a treatment provided no plant growth benefits but waiting 13 months before replanting appeared to protect against some components of the replant problem.

The application of marigold residues or water extracts of marigold also produce anaerobic conditions in soil. With marigold this occurred without the creation of a biological vacuum (see Addendum 3). There is also a residual phytotoxicity associated with marigold use so in our treatments we applied 40 inches of water 30 days after the marigold tea to wash out the phytotoxicity. This washing process was not successful and marigold treatments tended to produce poorer plants than the nontreated, especially where the replant problem was most severe.

Planting New Rows 10 Feet Off Center

This approach gives visible growth benefit and plant biomass the first year after planting but plants seemed to slow down in the second year. There was no benefit relative to nematode control.

Crop Rotation for 18 Months

Crop rotation benefited growth of vines especially. Each of the rotation crops was antagonistic to the nematodes present but old tree roots protected the nematodes within. Our repeated irrigations of the rotation crop did not appear to rot old roots or hatch out the nematodes from within. Replants that followed the rotation crops grew very well as we appeared to get past some of the replant problem. After 2 years the old peach and plum roots were dead but dead roots continued to be a source of root lesion and citrus nematodes, presumably surviving as eggs within. This treatment needs to be evaluated where ectoparasites are the only soil pest problem.

Systemic Herbicides to Kill Remnant Roots

For stone fruits and almond we have reported 80% kill of remnant Nemaguard roots and 40% kill of remnant plum roots 60 days after a 2% foliar application of glyphosate. Two years after the Roundup treatment, remnant roots still contained viable root lesion and citrus nematodes. These nematodes must be surviving as eggs within the dead root tissues. Replanting trees and vines 18 months after the glyphosate treatment resulted in substantial plant growth, as though some of the replant problem had been controlled by the glyphosate treatment and 18 months waiting. This treatment should be evaluated where the endoparasites are either not a problem or resistance to them is available.

With grapes neither 2% or 3% glyphosate treatment nor a 2% Garlon treatment has given adequate root kill one year after fall treatments. Garlon did provide thorough kill in the surface 1 foot of roots whether it was applied to a decapitated trunk or as a foliar spray.

With walnuts our work was conducted on 5-year-old Paradox and NC Black seedlings. Products evaluated included Roundup, Garlon, and 2,4-D applied to foliage at various rates to 3% or applied to freshly cut stumps with and without diesel oil. A year later trees were backhoed and roots visually evaluated for a life line at 1 foot, 3 feet and 5 feet soil depths. Each of the treatments was applied to 10 trees. Two treatments provided 95% to 100% root death. They were Garlon and diesel or 2,4-D and diesel applied to trunks in October. The trunks had been sawn and the chain saw used to carve a shallow cup on the cut trunk. In fall 1995 these two treatments were repeated for comparison with diesel oil alone. The walnut roots showing death also contained many fewer root lesion nematodes one year after treatment so there is a possibility that decay of walnut roots is relatively more bothersome to the root lesion nematode than is the decay of old peach roots. Work with these two herbicides needs to be conducted on older walnut groves.

Rootstocks

The value of soil pest resistance is useful after the trees or vines become established (see Addendum 4). Some rootstocks are actually more sensitive to the replant problem than own-rooted trees or vines. The suggestion that rootstocks will negate the need for soil fumigation has validity only if the rootstocks have actually been screened for growth in the presence of the replant problem.

In Summary

We have now reached the point where certain treatments are ready for field evaluation in certain field settings. Our research is now taking two directions. First, we need to continue small plot evaluations in our search for additional root killing agents of any kind. Second, we need to conduct field evaluations of combinations of the successful treatments listed above. These include:

1) Use of Telone or Vapam drench through existing micro sprinklers or drippers where resistant stocks are to be used or nematodes are not present.

2) Use of Vapam at 100 to 150 gallons/acre where ectoparasites are the problem.

3) Use of Urea drench followed by Sudan grass where root kill has been accomplished by some other means. We are ready to do this in walnuts.

4) Use of high rates of Vapam then waiting one year.

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MBAO Presentation, San Diego
November 1995
Addendum 1

MITIGATING THE VOLATILIZATION ASSOCIATED WITH TELONE

by
Michael V. McKenry and Tom Buzo

In 1972 this author reported the volatilized amount following a 280 kg/ha shankless, 30 cm deep injection of 1,3-Dichloropropene (1,3-D) in a drying soil to be 2% of the applied. Using shanks the volatilized amount could reach as much as 20% depending on the attention given to filling and compacting of soil behind the delivery shanks (1). Eighty-five percent of the volatilization occurred between day 1 and day 5 with the peak amount on day 3. Excessive volatilization and the subsequent 1990 suspension of 1,3-D use in California prompted the development of new shank delivery designs, maximum treatment rates of 135 kg/ha, and higher soil moisture content at the time of treatment (2). As a consequence, 1,3-D is now permitted for selective use in California. Unfortunately, in old vineyard and orchard sites treatment rates of 400 kg/ha applied to a dried soil are required to kill remnant roots down to 1.5 m depth and provide control of endoparasitic nematodes to 99.5% of the nontreated as much as two years after treatment (3).

There are at least three approaches that may be used to mitigate 1,3-D volatilization at these higher treatment rates. Sealing the field surface with a poly film tarpaulin doubles the treatment cost but also presents special exposure problems during tarpaulin removal. A second approach involves delivery of 1,3-D at 75 cm depth instead of the usual 30-45 cm depth. With shank traces properly filled and compacted there would be less of the 1,3-D and it would not reach the field surface for 48 hr (1). The use of moveable sprinklers utilized intermittently to produce a surface seal between 36 and 120 hr after treatment should be evaluated.

A third approach, and the one we have studied most, involves drenching of the field with 15 cm-ha water containing 366 kg/ha emulsified 1,3-D uniformly injected into it (3). Two years after making such a treatment it is now apparent that each of seven selected tree and vine crops planted 6 mo after treatment has grown comparable to that achieved following shanked methyl bromide or 1,3-D. Control of root lesion nematode, *Pratylenchus vulnus* and citrus nematode, *Tylenchulus semipenetrans*, one year after treatment was 99.5% of the nontreated.

In two separate drench sites we also monitored 1,3-D volatilization. Both sites involved a dripper emitter located at each 30 cm interval across the field, but in one site they laid on the field surface and in the other they were buried 30 cm deep. Unfortunately, the water infiltration rate for this soil was closer to 15 cm in 10 hr rather than the preferred 15 cm in 8 hr or less. Puddling occurred in the buried-emitter site as well as the on-surface site. Two weeks of continuous air monitoring from a point 15 cm above the field surface revealed that two-thirds of the volatilization from the surface drip occurred in the 12 hr period during application. Volatilization from the buried drip was half of that from the surface drip with peak volatilization occurring in the 12 hr period just after application. These data suggest that by drenching 1,3-D one can reduce volatilization as it becomes locked into the soil profile with water. A reusable poly film tarpaulin may need to become a component of the drenching device when broadcast treatments are made in soils with slower water infiltration.

A fourth approach with 1,3-D is now apparent. Emulsified 1,3-D delivered via existing low-volume irrigation systems can provide kill of tree and vine roots before removal of the planting. Minimal 1,3-D volatilization would occur because 1) less 1,3-D would be used per hectare and 2) puddling of water in that area can be kept to a minimum. Strip treatments such as this would only be applicable where resistance to soil pests is also available.

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MBAO Presentation, San Diego
November 1995
Addendum 2

FIRST-YEAR EVALUATION OF TREE AND VINE GROWTH AND NEMATODE DEVELOPMENT FOLLOWING 17 PRE-PLANT TREATMENTS

by
Michael McKenry, Tom Buzo, and Stephanie Kaku

In a two hectare plum replant site three separate experiments were conducted. On half the site trees were removed, soil was ripped to 0.7 m depth and a dual application of 366 kg/ha methyl bromide (MB) was compared to 40 days flooding or a 732 kg/ha drench of methyl isothiocyanate (MIT). The plot was split with rootings of Nemaguard Peach, Black Walnut, Dr. Huey Rose, Marianna 2624 Plum, and Teleki 5C Grape either replanted in 6 mo. or after 18 mo. of crop rotation involving Barley, Sorghum x Sudan and Cahaba White Vetch.

On the adjacent one hectare the existing plum trees received a foliar spray of 2% glyphosate 60 days before their removal. The field was then planted to barley. After discing under the barley, ripping to 1.3 m and resettling the soil, treatments were drenched into the surface 1.6 m of soil profile. To this half the field all trees and vines were replanted a full 18 mo. after tree removal. Six months after the glyphosate treatment there was 80% kill of old Nemaguard roots and 40% kill of old plum roots. Populations of *Pratylenchus vulnus* nematode were still present within the root systems two full years after the glyphosate treatment. Populations of *Tylenchulus semipenetrans* nematode also remained alive around the plum roots two years after the glyphosate.

Each October after replanting the growth of five reps of each of five plant cultivars was destructively sampled. Plant growth was compared to the nontreated that were replanted 6 mo. after tree removal. For example, several treatments produced plants that were 7 to 11 times larger than the nontreated. The multiple for plant growth improvement was averaged across the five plant cultivars to provide a single value which depicts relative plant growth.

Four treatments provided nematode control one year after treatment that was 99% of the nontreated. These four treatments also provided plant growth 7.0 to 8.5 times better than the nontreated that was planted 6 mo. after tree removal. The four comparable treatments included: 1) MB at 366 kg/ha followed by an 18 mo. crop rotation; 2) MIT at 732 kg/ha followed by 18 mo. crop rotation; 3) Glyphosate-treated site followed by a drench of emulsified 1,3-D at 366 kg/ha and 4) MB at 366 kg/ha replanted after 6 mo.

A fifth treatment, glyphosate followed by acrolein drench at 366 kg/ha gave plant growth of 8.3 times the nontreated but after one year the nematode control averaged only 50% among the three most susceptible hosts.

Three treatments that provided plant growth comparable to the above-mentioned but provided no long-lasting nematode relief included: 6) 40 days flooding then 13 mo. sorghum x Sudan and vetch; 7) glyphosate followed by MIT drench at 366 kg/ha and 8) glyphosate followed by 18 mo. fallow.

Replanting 3 m away from the old tree row provided 2.6 times more growth in the first year but no nematode relief.

Flooding for 40 days and planting within two months did not provide kill of remnant roots or nematode reductions and plant growth was only 1.4 times the nontreated.

Fallowing or crop rotation for 18 mo. greatly improved growth of replants but didn't provide adequate nematode relief against endoparasitic nematodes which remained in roots.

A drench of urea gave 95% nematode relief in soil but didn't reduce populations of endoparasitic nematodes within roots. A drench of marigold tea plus urea followed in one month by 1 ha-m irrigation gave control of soil-dwelling nematodes without creating a biological vacuum. Plant growth of 4.6 times the nontreated indicated, however, that a phytotoxic residue remained in the soil.

A drench with 366 kg/ha chlorine gave surprising benefit to the growth of peach but nematode control in soil and in remnant roots was inadequate. Drenches are very useful in sites where 15 cm water can be delivered within 8 hr. These drenches were each delivered throughout the surface 1.7 m of soil using a portable soil drenching device.

Table 1. Summary of plant and nematode responses in the two years following various soil treatments.

Treatment Product, Rate and Method					Nematode Control		Plant Growth Compared to Nontreated Planted After 6 mo.	
Biocide	Rate	Kg ai/ha	mg ai/L Water	Injection Method	One Year After Planting	Two Years After Planting	First Year	Second Year
MB then 18 mo. rotation	350 lb/ac	392	Variable	Shank	99%+		7.14 x	
Vapam then 18 mo. rotation	200 gpa	732	490	PSDD-Uniform	99%+		8.54	
Roundup then 1,3-D	33 gpa	366	245	PSDD-Uniform	99%+		7.00	
MB then 6 mo. fallow	350 lb/ac	392	Variable	Shank	99%+	99%	7.28	3.70
Roundup then Acrolein	--	366	980	PSDD-Wave	50%+		8.34	
40 day flood then 13 mo. fallow	--	--	--	--	Poor		7.00	
Roundup then marigold tea	7.5 ton/ac	16,800	27,750	PSDD-Uniform	Poor		4.60	
Vapam then 6 mo. fallow	200 gpa	732	490	PSDD-Uniform	Poor	None	3.28	2.48
Roundup then Vapam, fallow	100 gpa	366	245	PSDD-Uniform	None		8.02	
18 mo. crop rotation (barley, sudan, vetch	--	--	--	--	None		3.56	
Roundup then low bi urea	654 lb/ac	732	490	PSDD-Stacked	None		6.52	
Roundup then chlorine	--	366	980	PSDD-Wave	None		6.56	
Roundup then 18 mo. fallow	--	--	--	--	None		7.06	
Nontreated then plant 10 ft. away after 6 mo.	--	--	--	--	None	None	2.44	1.66
Roundup then fallow 18 mo. then plant 10 ft. away	--	--	--	--	None		3.76	
40 day flood then plant in 2 mo.	--	--	--	--	None	None	1.38	1.24
Nontreated plant after 6 mo.	--	--	--	--	None	None	1.00	1.00

MBAO Presentation, San Diego
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Addendum 3

EVIDENCE FOR THE DEVELOPMENT OF A "BIOLOGICAL VACUUM" IN SOIL FOLLOWING PRE-PLANT SOIL FUMIGATIONS OR DRENCHES

by
Michael McKenry, Stephanie Kaku, and Rulon Ashcroft

Soil sterilization reduces soil microbe populations that are beneficial as well as those that are detrimental to plant growth. Following soil fumigation, plant parasitic nematode species can be reduced to nondetectable levels (1). Subsequently-planted trees or vines respond favorably to the treatment for at least these reasons: 1) The lack of soil pests, 2) The lack of microbes not usually considered as pests or disease incitants, and 3) These plants also exhibit an "increased growth response" (IGR) due to changes in nutrient availability (2). Participants in soil fumigations have occasionally observed a fourth phenomenon in that the first microbes that are reintroduced into fumigated soil develop greater abundance than if they were introduced into nonfumigated soil. These organisms appear to be filling a "biological vacuum" but since the treated vines or trees also grow many times faster than the nontreated it has been difficult to quantify the impact of a biological vacuum. In a separate paper at this conference an example involving Vapam was presented illustrating the importance of remnant roots as a protective habitat for endoparasitic nematodes and the ability of those nematodes to rebuild quickly within treated soil. In conducting those same experiments we inadvertently observed a "biological vacuum" effect in more quantifiable terms.

Six months before various tree and vine crops were replanted a variety of "softer" soil drench treatments were compared. Nematodes in the field included *Pratylenchus vulnus*, *Tylenchulus semipenetrans*, and *Paratylenchus hamatus*. The latter nematode is usually an ectoparasite but in a few crops including Dr. Huey Rose this nematode occurs as an endoparasite. In fact, the bareroot roses we planted to the field were contaminated with a low population level of *P. hamatus* at planting. A drench treatment of 366 kg/ha 1,3-D resulted in no plant parasitic nematodes on six of seven hosts. Six months after planting, however, a population of *P. hamatus* was present at threefold the level present in the nontreated sites when planted to rose. By contrast, the nontreated sites had *P. hamatus*, *P. vulnus*, and *T. semipenetrans* across all seven crops. This threefold population increase over the nontreated also occurred after drenches of Vapam and Acrolein (see Table 1). By contrast, treatments of marigold tea plus urea resulted in *P. hamatus* populations on rose very similar to those of the nontreated, and very similar to those on the other crops planted. In this experiment the marigold and urea treatment provided tree and vine growth at slightly less than those treated with Acrolein, 1,3-D or Vapam. For tree and vine crops the existence of a biological vacuum carries two significant impacts. First, we should be learning how to add back or stimulate beneficial organisms after soil treatment. Secondly, treatments that might miss specific life stages of soil pests need to be evaluated for at least two growing years after treatment. The MIT and Acrolein treatments, for example, can be expected to result in very high populations of *P. vulnus* in the second year.

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Table 1. Plant biomass and nematode populations one full year after planting *P. hamatus* contaminated roses into infested soil that had received three conventional biocides compared to a "softer" treatment of marigold tea plus urea.

Soil Treatment	Plant Growth (g/plant)	Nematodes/250 cm^3 soil *P. hamatus*	Nematodes/250 cm^3 soil *P. vulnus*
1,3-D	1185 ns	742 a	0 a
MIT	1108	802 a	227 a
Acrolein	1068	743 a	81 a
Marigold Tea Plus Urea	779	243 b	295 a
Nontreated Control	969	204 b	1292 b

Variance of the means was analyzed and subjected to a T test. Means in each column followed by a different letter are significantly different from each other ($\underline{P} < 0.05$).

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Addendum 4

IT IS A LONG ROAD FROM THE FINDING OF A NEW ROOTSTOCK TO THE REPLACEMENT OF A SOIL FUMIGANT

by
M. V. McKenry and J. O. Kretsch

Culminating eight years of small plot evaluations we recently reported the finding of three grape rootstocks with "broad nematode resistance." Our first four years were spent identifying the nematode susceptibilities of existing rootstocks (see Table 1). Meanwhile, Dave Ramming of the USDA Plant Breeding Station in Fresno, CA was in possession of more than 500 mature vines that had been collected over decades and occasionally submitted to various screenings. Knowing our specific needs, we set out to find sources of resistance to three very aggressive Meloidogyne populations. Our definition for resistance is a lack or near lack of reproduction by the nematode on the cultivar over a two-year period. Thirteen of the USDA cultivars met our objective so we looked further to identify, one species at a time, the breadth of their resistance to each of the other common nematode species on grape in California.

The notion that these three rootstocks or any others will replace methyl bromide is premature. First, methyl bromide solves the replant problem by killing nematodes and most everything else in soil. Although these rootstocks do not permit nematode reproduction they may not stop nematode feeding. Since remnant grape roots can survive in soil as much as a decade after vine removal, there can be an abundant supply of nematodes and viruses in the proximity of newly planted grape roots.

To answer the question of how well these potential rootstocks replace soil fumigation, at least three additional screenings are needed. First, using four or five different replant soils, how well do the rootstocks grow compared to nonreplant or fumigated soil? This test is now underway. Second, do these rootstocks tolerate nematode feeding? Tolerant rootstocks are the ones that grow as well in the presence of nematode feeding as in their absence. Freedom and Ramsey grape rootstocks, for example, actually grow significantly better (35%+) in the presence of limited nematode feeding. By contrast, cultivars of *V. vinifera* commonly grow significantly less (12-50%) in their first year of exposure to nematode feeding. The third screening should be across a variety of common soil pests including Phylloxera *Daktalosphaeria vitifoliae*, Phytophthora spp. and *Armillaria mellea* as well as their performance in droughty soils, calcareous soils, shallow soils, etc. It has been our experience that field-level rootstock trials can go on in abundance for decades and provide only partial answers to specific soil and pest questions. We need to be more efficient at learning the limitations of rootstocks.

If there is inadequate resistance or tolerance by the rootstock to the replant problem, growers will continue to need either strip or spot treatments of soil fumigant before planting. Or, with broad nematode resistance planted to primarily nematode problem sites we may be able to use "softer" pre-plant treatments. For example, growers with an existing dripper system may be able to apply products at biocidal rates to mitigate some of the replant problem and then rely on broad nematode resistance for the lifetime of the vineyard. One point to be remembered is that resistance to nematodes is a helpful tool once the vineyard is established but there are no examples of it being useful in solving replant problems where vineyards or orchards are removed one year and replanted the next. The second point is that there are no universally acceptable rootstocks, whereas soil fumigants have a history of very broad acceptance among a range of high-value crops.

Table 1. Susceptibility or resistance of various grape cultivars to various nematode populations.

	Populations of *Meloidogyne* spp.									*Xiphinema* spp.				
Rootstock	Mi	Mj	Mm	Ma pt H	Ma pt F	Mc-L	Mc-D	Pv[1]	Ts[2]	Xi	Xa	Xc-1	Xc-2	Cx[3]
Ramsey	R	R	R	HS	HS	S	R	R	S	9	71	-	-	100
Freedom	R	R	R	HS	HS	R	S	SS	S	2	10	S	-	50
Dogridge	R	R	R	HS	HS	-	-	S	S	24	15	-	-	123
1613C	R	R	MR	HS	HS	S	S	SS	S	7	72	-	-	164
Harmony	MR	R	R	HS	HS	S	S	SS	S	24	52	-	-	35
Teleki 5C	SS	MR	S	HS	HS	-	-	S	S	9	72	-	-	65
Oppenheim-4	SS	MR	S	S	-	-	-	S	S	6	43	-	-	65
Schwarz.	S	MR	S	HS	HS	-	-	SS	S	5	13	-	-	42
039-16	S	S	HS	S	S	-	-	S	S	2	5	S	-	-
99R	HS	S	S	S	-	-	-	S	SS	54	28	-	-	71
3309C	HS	S	HS	HS	HS	-	-	SS	S	20	44	-	-	136
Thomp. S.	S	S	HS	HS	S	S	HS	S	S	100	100	100	-	100
Flame S.	S	S	HS	S	S	S	S	S	S	154	32	-	-	185
Rubired	S	S	S	S	-	-	R	S	SS	365	51	-	-	59
K51-32	R	SS	S	S	-	-	-	R	S	2	52	-	-	272
Grenache	-	-	-	-	-	-	-	-	-	-	-	-	-	251
<u>USDA Selections</u>														
6-19B	R	R	R	SS	-	R	MR	R	R	15	2	1	30	12
10-17A	R	R	R	R	-	R	R	R	R	2	-	1	16	24
10-23B	R	R	R	R	-	R	R	R	R	5	-	1	7	19
<u>Ramsey x Schwarzmann Selections</u>														
RS-9	R	R	R	R	R	R	R	-	-	-	-	-	-	-
RS-3	R	R	R	SS	-	-	-	-	-	-	-	-	-	-

Resistant R = <0.2 nematodes/gr root
Moderate resistance MR = 0.21 to 0.6 nematodes/gr root
Slightly susceptible SS = 0.61 to 3.0 nematodes/gr root
Susceptible S - 3.1 to 180 nematodes/gr root
Highly susceptible HS = 180+ nematodes/gr root

\- = no data

For ectoparasites population buildup is expressed as a percentage of that level built up on Thompson Seedless. Levels of 100 are normal, levels of 10 or less indicate resistance.

[1] *Pratylenchus vulnus*

[2] *Tylenchulus semipenetrans*

[3] *Criconemella xenoplax*