EFFECTS OF SEVERAL NEMATODE-RESISTANT ROOTSTOCKS ON VINE VIGOR, CROP LEVEL, AND NUTRITION WITH THE GRAPE VARIETY, GRENACHE[1]

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In recent years, California vineyardists have shown an increasing interest in the use of vigorous nematode-resistant grape rootstocks. In situations characterized by sandy soils of low fertility several varieties of these stocks have performed quite well (4, 7). When planted in more fertile locations, however, they have often shown excessively vigorous vegetative growth, reduced flower fertility, and a resultant reduction in yields of fruit at harvest.

A number of old and well established cultural practices in commercial vineyard management, such as pruning, topping, cluster thinning, and girdling, are designed to favorably influence flower bud differentiation, fruit set, and seed development. A number of vineyard studies have been conducted over the years to evaluate the cause and extent of these effects (3, 5, 8, 10, 11). It can be concluded from these studies that the relative availability of organic nutrients has a distinct influence upon the reproductive phase of plant growth. The initiation and maturation of the floral part of the grape, especially the development of pollen grains and megaspores, and the processes of fertilization all seem to be closely governed by the supply of carbohydrates available in the vine at the time that these important processes are taking place.

Poor fruit set is common on vines with excessively vigorous shoot growth. Winkler (10) has shown conclusively that severely pruned vines give shoots with increased vigor, less fertile flowers, and reduced fruit set. Today, it is a standard recommendation for growers to balance the amount of fruiting wood left at dormant pruning with the amount of vegetative growth produced in the past season (6, 12).

Investigations in both Europe (1, 5) and California (2, 4, 7) have confirmed the fact that the inherent nature of the rootstock can influence the scion's behavior. It has been shown that certain stocks can be classified for their great vigor and that this rootstock vigor can be expressed in the scion by high rates of vegetative growth, increased "coulure", or berry shatter, and a low level of fruit production. The California experiments have shown specifically that certain stocks cause their scions to fluctuate markedly in yields while regularly producing over-abundant amounts of vegetative growth. Singled out were the vigorous rootstock varieties Rupestris St. George, Dogridge, and Salt Creek[3]. In some instances the stock Solonis x Othello 1613 has caused similar effects, especially when grown on fertile soils. Recently, it was felt desirable to direct additional studies toward devising techniques which would better utilize this scion vigor and which would conceivably direct the energies of these strong-growing vines toward the production of greater amounts of harvestable fruit.

METHODS AND RESULTS

An experimental planting of vines including several nematode-resistant stocks

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[3] The origin of the selection used in these trials is questionable. It appears to be of a **V champini** type, closely related to Dogridge, and should not be confused with another variety, named Salt Creek, that was selected from **V. doaniana.**

grafted to the scion variety, Grenache, was set out in the spring of 1956. The vines, located in a cooperating grower's vineyard near the town of Manteca, in San Joaquin County, are on a deep, well-drained, sandy loam soil of the Hanford series. This fairly fertile soil was known to be infested with root-knot nematodes *Meloidogyne* spp., at the time of planting. Planted in addition to the own-rooted Greache were two or more rows of twenty vines of Grenache grafted on each of five stocks. The vines, spaced 8 feet apart in rows spaced at 12 feet, were trained to the bilateral cordon and spur pruned. At dormant pruning the number of fruiting spurs retained was adjusted according to the vigor of the vines on the different stocks, and all were daubed with a zinc sulfate solution, using 1.5 pounds per gallon of water, for the control of little leaf, a frequent condition when this vigorous scion is grown on sandy soils. Four or five applications of approximately six inches of irrigation water were made annually during the growing season. Along with certain special treatments which were begun in 1962, the crop was weighed each year and a fruit sample of twenty clusters was taken from each row for analysis.

The general characteristics of the nematode-resistant stocks used in the trial have been described (7). Table I lists these stocks and presents the average annual yields from two rows on each from 1959, the first year of fruit production, through 1964. Although the six-year average indicates rather comparable yields among the stocks, the variability among years is somewhat greater on the more vigorous Dogridge and Salt Creek, especially during the last three years measured, while the own-rooted Grenache vines and those on 1616 and 5-A have produced more uniformly among years. Following the heavy crop in 1962, the amount of fruiting wood retained was increased on the vigorous stocks, adding two to four additional spurs per vine on the Dogridge grafts, increased somewhat less than this on Salt Creek and 1613 (depending upon the growth of the individual vines in each of the rows), and reduced about one spur per vine on the own-rooted Grenache. In spite of this additional fruiting wood, the yields on these three strong stocks were not increased the following two years when compared with the own rooted vines; and in fact, showed a considerably greater decrease in relation to the 1962 yields.

The reduced fruiting efficiency of the vines on Dogridge, the most vigorous stock in the trial, is illustrated in table 2. In spite of an addition of more than six spurs per vine, the yield average for 1963 and 1964 is only slightly higher on this stock than on Grenache and slightly less than on Salt Creek and 1613, where spur numbers averaged nearly three and five less, respectively. This is reflected in a marked reduction in average yield per spur on the Dogridge vines. Cluster weights, and to a lesser extent berry weight, on all the stocks are considerably under those on the own-rooted

TABLE I

Annual Yields of Fruit per Vine in Kilograms, from the Manteca Rootstock Trial Variety, Grenache, Planted in 1956

Rootstock	1959	1960	1961	1962	1963	1964	6 yr. Average
Solonis x Othello, 1613	12.4	21.4	18.9	37.2	28.9	26.4	24.2
Dogridge, **V. Champini**	13.0	19.0	21.7	40.9	28.6	26.3	24.9
Salt Creek, **V. Champini**	11.0	19.5	22.4	38.6	26.4	33.4	25.2
Berlandieri x Riparia, 5-A	9.6	19.6	17.8	33.7	30.2	24.1	22.5
Solonis x Riparia, 1616	11.2	19.6	14.3	32.0	23.6	22.5	20.5
Grenache, own roots	8.6	19.5	16.6	28.8	26.2	27.1	20.2

Grenache vines, with Dogridge showing the greatest reduction.

The high vigor of the grafted vines, especially those on Dogridge, once again, is shown in the data on weight of prunings per vine. When this is expressed on a per-spur basis, however, the difference between the individual stocks is reduced, although not completely overcome. This is shown by the ratios in table 2, where the pruning weights and the fruit production are compared on a per-spur basis. The relatively poor fruiting efficiency of the vines grafted on Dogridge is borne out. This reduction in crop per fruiting spur can be partially explained by the considerably smaller clusters and slightly reduced berry size on the Dogridge vines. To account entirely for this deficiency in crop, however, the number of clusters per vine must also be considered. By using the data on yield per vine and the sample cluster weight, a calculated number of clusters per vine can be obtained. these data, shown in table 2, when compared with the spur counts, would indicate that, in addition to the smaller clusters produced, a deficit must also exist in the number of clusters initiated in the buds of the vines grafted on Dogridge. Figure 1 presents the appearance of typical clusters from four of the combinations in this trial. The effect of the vigorous stocks, Dogridge and Salt Creek, on berry set and cluster size is quite evident. Figure 2 shows the prunings obtained in 1963 from five vines in these same rows, illustrating the excessively strong growth of the Dogridge vines.

Earlier reports (3, 8, 11) have shown that vine treatments such as defoliation, girdling, topping, and certain hormone sprays can affect fruit set and berry development. In the spring of 1962 and 1963, several of these were applied to vines on two of the stocks, 1613 and Dogridge, and to own-rooted Grenache vines. The aim was to modify the levels of organic nutrients present in the vine, especially in the vegetative parts around the clusters, during the critical bloom period and to measure their effects on yield. The treatments employed were: (1) to girdle the trunk, removing a 1/16-to-1/8-inch ring of bark, (2) to top (cut back) all primary shoots back to the

TABLE 2

Cluster Characteristics and Crop Production as Yield per Fruiting Unit and Their Relation to Vegetative Growth Measured as Prunings: Average of Two Rows on Each Stock for the Years 1963 and 1964

Rootstock	Yield per vine	Spurs per vine	Yield per spur	Cluster weight	Weight of[a] 100 berries	Clusters[b] per vine	Clusters per spur	Prunings per vine	Prunings per spur	Ratio of prunings to fruit
	Kilograms	....	Kilograms	grams	grams	....	....	Kilograms	Kilograms	
Solonis x Othello, 1613	27.6	14.2	1.95	355.0	161.0	77.8	5.5	4.1	0.29	6.74
Dogridge, **V. Champini**	27.4	19.0	1.45	343.5	157.5	80.8	4.3	5.8	0.31	4.73
Salt Creek **V. Champini**	29.9	16.2	1.84	389.5	171.8	77.3	4.8	4.0	0.25	7.38
Berlandieri x riparia, 5-A	27.2	14.0	1.94	399.5	196.2	68.4	4.9	3.5	0.25	7.84
Solonis x riparia, 1616	23.0	12.3	1.88	378.5	176.6	61.2	5.0	3.1	0.25	7.44
Grenache, own roots	24.0	12.7	1.88	416.5	185.5	57.4	4.5	2.7	0.21	8.96

[a] Weight of 100 seeded berries.
[b] Number of clusters calculated from cluster weight and yield per vine.

first nearly mature leaf, usually removing 6 to 10 inches of tip growth; and (3) to spray, wetting all foliage, with a 500-ppm solution of maleic hydrazide. Initial treatments were applied at early bloom, on May 10 in 1962 and on June 3 in 1963. Each treatment was replicated three times with four vines per replicate on each stock. In addition, near the end of bloom in 1962, the developing lateral shoot growth on the topped vines was pinched, removing up to one inch of the tip, or about one-half their total growth, five days after the initial treatments. At this time, also, the vines treated with maleic hydrazide were resprayed. Signs of reduced vigor were evident in the own-rooted Grenache on both the girdled and topped vines at harvest in 1962. A slight yellowing, with a mild mottle of the leaf, and finally a noticeable reduction in total shoot growth, was evident late in the summer on all vines sprayed with maleic hydrazide. For these reasons, in 1963 only two vines in each of the replicates were used for each of the treatments described above. A foliar

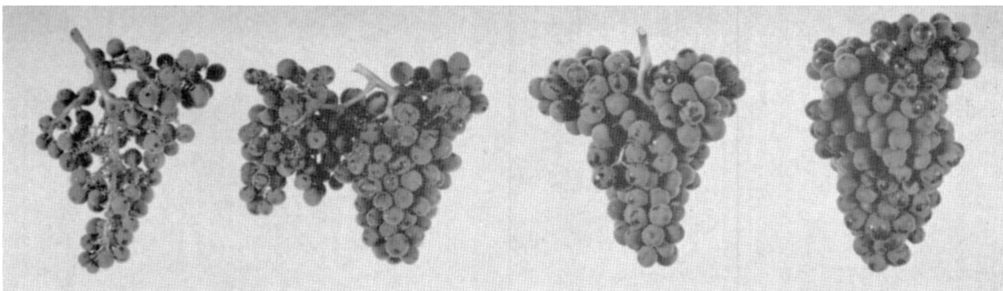

Figure 1. Grenache clusters produced on four stocks. Left to right, Dogridge, Salt Creek, 1613 and own rooted Grenache vines; illustrating the variability shown in berry set and cluster size.

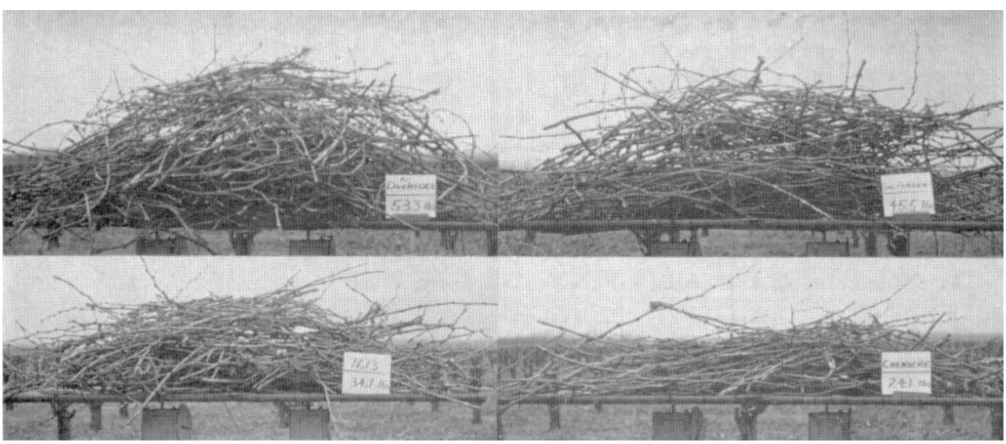

Figure 2. The prunings obtained from five vines on each of four different stocks illustrating the extreme difference in vegetative vigor observed. Upper left, Dogridge; upper right, Salt Creek; lower left, 1613; lower right, own rooted Grenache.

sample was obtained from each replicate at late berry shatter, or approximately four weeks after the initial vine treatment. The sample was made by compositing the tissue from a single fruitful shoot arising from a spur on each vine. This shoot was removed at the first node above the upper cluster. These samples were oven dried and analyzed for total carbohydrate measured as the sum of available sugars plus starch by procedures described by Winkler and Williams (13) and Phillips (9), and for total nitrogen content by the Kjeldahl procedure. Finally, the yield from each vine was weighed at harvest. Table 3 presents the data gathered from these treatments. In both years all girdled plots showed a marked increase in carbohydrates and, except for the own-rooted Grenache in 1963, a decrease in total nitrogen. This is reflected in a very significant elevation of the carbohydrate-nitrogen ratio in all these plots. However, only the Dogridge vines showed a yield response to this shift in nutritional balance. Topping did not increase carbohydrate levels and, in fact, appears to have reduced the amounts present in 1963. Maleic hydrazide sprays, although producing a visible affect on the vegetative parts of the vine, altered neither the nutrient levels nor the yields. It is suggested that the timing of these spray applications was not proper. Earlier spring treatments, well ahead of bloom, would possibly have advanced the time of the growth-retarding effects into the period of berry set.

Coombe (3) has discussed in detail the parasitic influence of new vegetative growth during the critical period of bloom and berry set. He related the ultimate influence of the vine treatments which he used to an alteration of the levels of available carbohydrates during this period and of this shift in nutrients on the hormone balance in the developing flowers. It seems that this same concept can be extended to the influences on the initiation and differentiation of flower primordia in the buds of the vine during the summer, as Winkler (11) has indicated. In the studies described here, the girdling treatments, by increasing yields only on the more vigorous vines, support Coombe's suggestions that unbalanced nutrition is closely related to excessive vine vigor and reduced berry set. The fact that a fifty percent increase in the fruiting wood left on the vigorous vines did not materially reduce the amount of prunings obtained, or elevate the crop above the less vigorous vines, is significant in the light of Winkler's data. This lack of pruning response would indicate that a limit had been reached in the effective amount of fruiting wood that can be retained per vine with this type of vine training and support. No doubt a more elaborate trellis system and a more extensive framework of old wood developed on the vine would make it possible to position additional amounts of fruiting wood more favorably at dormant pruning, and perhaps would elevate the fruitfulness of the individual buds retained.

SUMMARY

A regulated level of pruning, in which the number of fruiting units retained is balanced with the past vegetative growth of the vine, did not entirely overcome the low-yielding tendencies of very vigorous grafted vines. Fruiting efficiency of the individual spur, based on the ratio of prunings to fruit produced, was markedly lower from vines on the very vigorous stock, Dogridge, and highest on the own-rooted Grenache vines. Over the six-year period that harvest records were obtained, the heaviest-yielding vines and those showing the best balance between growth and fruit production were on the *V. Champini* selection, Salt Creek. Total carbohydrate content was markedly increased and total nitrogen level decreased in the shoots by girdling during bloom. Only the yields of the vigorous vines on Dogridge were increased by this treatment. Topping the vine at bloom did not change carbohydrate levels in the shoots at the time of berry shatter, but gave some reduction in vine vigor. A growth retardant, maleic hydrazide, used at 500 ppm as a foliar spray during bloom, was not effective in changing nutrient levels in the shoots. However, evident leaf symptoms and reduction in shoot elongation was noted late in the growing season.

TABLE 3

The Effect of Several Bloomtime Treatments on Nutrient Levels in Shoots Sampled at Berry Shatter and on Fruit Yields of Grenache Vines on Three Rootstocks, Average of Three Replicates

		1962				1963			
		Total CHO[a]	Total Nitrogen	Ratio C/N	Yield	Total CHO[a]	Total Nitrogen	Ratio C/N	Yield
Rootstock	Treatment	% dry wt.	% dry wt.	- - -	Kgs./Vine	% dry wt.	% dry wt.	- - -	Kgs./Vine
Dogridge, **V. Champini**	Control	4.56	2.23	2.04	41.6	5.23	1.53	3.42	30.9
	Girdled	7.34	1.98	3.71	45.5	8.67	1.49	5.82	37.3
	Topped	4.86	2.45	1.98	42.9	4.85	2.11	2.30	34.7
	M H Spray	4.71	2.48	1.90	37.4	6.13	1.96	3.13	32.7
Solonis x Othello, 1613	Control	5.79	2.61	2.22	30.9	8.18	1.68	4.87	27.8
	Girdled	8.99	2.13	4.22	31.1	10.55	1.17	9.02	27.9
	Topped	5.53	2.47	2.24	28.8	6.74	1.61	4.19	25.2
	M H Spray	5.68	2.57	2.21	28.8	7.69	1.68	4.58	25.4
Grenache, Own Roots	Control	4.64	2.42	1.92	33.6	7.43	1.55	4.79	29.2
	Girdled	9.42	2.11	4.46	35.4	9.13	1.71	5.34	28.2
	Topped	4.66	2.30	2.03	34.2	6.07	1.73	3.51	29.6
	M H Spray	5.14	2.41	2.13	26.6	7.46	1.95	3.83	28.1
	$d_{.05}$	0.93	0.26	......	3.49	0.78	0.19	......	NS
	$d_{.01}$	1.27	NS	......	4.78	1.06	0.26	......	NS

[a] Carbohydrates, as the sum of sugars plus starch.

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