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Performance of table grape cultivars on different rootstocks in an arid climate[1])

by

P. Spiegel-Roy, J. Kochba and S. Lavee

Introduction

The object of this study was to test rootstock response under the conditions prevailing in the arid, southern part of Israel (the Negev region). As this region has not been known in the past to be infested with *Phylloxera vastatrix*, no previous information on the response of grafted vines in this area existed.

The rootstock experiment was initiated in 1954 in a loess soil of aeolic origin in the eastern part of the Negev. Precipitation is low and erratic, with irrigation practiced the year round. In view of the prevailing climatic and edaphic conditions, high priority was given to *V. berlandieri* × *V. rupestris* rootstocks because of their reputed adaptation to warm calcareous soils (1, 7, 8, 9, 10). With *Phylloxera* not yet a limiting factor in this environment, all three varieties tested were also grown as own-root vines.

Materials and Methods

A fairly level and uniform loess soil, of a sandy loam nature, was chosen for the experiment. Characteristics of the soil are given in Table 1. Annual rainfall during the period of the experiment (1954—1968) varied from 100—500 mm, with a yearly average of 257 mm; rainfall is limited to the winter season.

Queen of the Vineyards, Muscat of Hamburg and Dabouki were bench-grafted in the nursery on Chasselas × *V. berlandieri* 41 B, *V. berlandieri* × Resseguier No. 2 × Rupestris Martin 11OR, *V. berlandieri* de Las Sorres × Rupestris du Lot 99R, *Solonis* × Rupestris du Lot 216-3Cl, *V. berlandieri* × Rupestris du Lot 140 Ru, *V. berlandieri* Resseguier No. 2 × Rupestris du Lot 1103 P, Mourvedre × Rupestris

Table 1

Soil data of vineyard at Gilat (Eastern Negev)

Depth of layer cm	Coarse sand %	Fine sand %	Silt %	Clay %	$CaCO_3$ %	Cl %	pH
0— 30	3.4	59.1	28.7	13.8	11.9—13.6	.002—.012	8.1—8.2
30— 60	2.5	41.7	37.2	18.6	15.5—21.1	.002—.004	8.2—8.3
60— 90	1.7	45.4	34.3	18.6	16.0—23.5	.003—.007	8.2—8.5
90—100	1.5	54.8	28.3	15.4	16.4—26.2	.004—.007	8.2—8.5
100—125	1.9	57.3	25.3	15.5	13.6—23.1	.002—.012	8.1—8.4

[1]) Contribution from The Volcani Institute of Agricultural Research, Bet Dagan, Israel. 1971 Series, No. 1986-E.

1202C and *V. berlandieri* × *V. riparia* 161-49C. *Vitis vinifera* varieties on their own roots (rooted cuttings) were included for comparison. The vines were planted during January 1954 in randomized blocks, with five replications of ten vines for each stionic (scion-rootstock) combination. Each variety was accorded a separate block.

The vines were trained to a horizontal-type trellis, established at 75 cm from the ground. During the first two seasons, spur pruning was practiced. Queen of the Vineyards was cane pruned during the last three years of the experiment. Adult vines of Dabouki were cane pruned, with 5—7 buds per cane. The vines started cropping in 1957. Dates of spring flush, flowering, harvest and leaf drop were recorded throughout the experiment. In the first year weight of prunings was determined for each vine individually. Subsequently, weights of prunings (to be referred to later in the text as "wood weight") of each replication were pooled. A similar technique was followed with yield determinations.

Total soluble solids (TSS) and acidity of fruit were determined, in addition to average bunch and berry weight. The degree of compactness of bunches was estimated according to a scale ranging from 0 to 5, with 5 representing maximum compactness (19). Fruit color was estimated according to a scale ranging from 0 (green) to 3 (black).

Results

Effect of rootstocks upon yield and vigor

The cumulative yields from 11 years of cropping for Muscat of Hamburg and Dabouki, and from 8 years of cropping for Queen of the Vineyards, are summarized in Table 2. The highest yield per vine was attained with Dabouki, followed by Muscat of Hamburg and Queen of the Vineyards. Queen of the Vineyards vines were, on the average, the most vigorous, and Muscat of Hamburg by far the weakest. The highest cumulative yields were obtained with own-root plants, followed by 41 B and 110 R with the Muscat variety, 41 B followed by 110 R, 161-49 and 1202 with Dabouki. Queen of the Vineyards on 161-49 proved to be the highest-yielding combination, followed by 1202 and 99 R. Own-root plants gave highest yields with Muscat, intermediate with Dabouki, and significantly below average results with Queen of the Vineyards. 216-3 performed poorly with Muscat, while 1103, 140 R and own-root plants gave the lowest yields with Queen of the Vineyards.

The correlation between vigor (determined by weight of prunings) and yield was very low with all three varieties. There are no indications, however, of an inverse relationship between vigor and yield. Some combinations, like Muscat of Hamburg on 41 B and 110 R, Dabouki on 41 B, and Queen of the Vineyards on 161-49, 216-3 and 41 B, show a higher total cumulative yield/cumulative prunings ratio than the other combinations with these varieties. It seems that with 140 R, 1103 and 1202, the balance of yield/vigor is more on the 'vigor' side with a definitely lower ratio of yield/weight of prunings. The same holds true to an even greater extent with own-root plants of Queen of the Vineyards.

Values obtained by dividing the ratio of cumulative yield/cumulative weight of prunings by the square root of cumulative weight of prunings[1]), showed high values with Muscat on 41 B and 110 R, with Dabouki on 41 B and 216-3 Cl, and generally lower values with Queen of the Vineyards on all rootstocks.

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[1]) The expression $\frac{Y/P}{\sqrt{P}}$ is desirable to place larger strees on weight of prunings, because of vigorous wines, rather than the normal yield unit, Y/P.

Table 2

Sum of the average annual yields, and weights of the prunings

Rootstock	Muscat of Hamburg Cumulative[1]				Dabouki Cumulative[2]				Queen of Vineyards Cumulative[2]			
	Yield	Pruning weight	Y/P[3]	$\frac{Y/P}{\sqrt{P}}$	Yield	Pruning weight	Y/P	$\frac{Y/P}{\sqrt{P}}$	Yield	Pruning weight	Y/P	$\frac{Y/P}{\sqrt{P}}$
	kg	kg	ratio	ratio	kg	kg	ratio	ratio	kg	kg	ratio	ratio
Own rooted	74.7 ± 2.6	15.7 ± 0.6	4.76	1.20	71.0 ± 4.2	16.4 ± 0.3	4.33	1.07	55.8 ± 1.7	18.6 ± 0.8	3.00	0.70
41 B	72.3 ± 2.8	13.3 ± 1.0	5.44	1.49	88.9 ± 5.1	14.3 ± 0.6	6.22	1.65	64.6 ± 3.3	15.9 ± 1.7	4.06	1.02
110 R	70.1 ± 2.6	12.7 ± 0.7	5.52	1.55	83.0 ± 4.1	19.5 ± 1.0	4.26	0.96	62.1 ± 4.1	16.0 ± 1.0	3.88	0.97
1202 C	69.1 ± 3.3	16.5 ± 1.3	4.19	1.03	76.2 ± 3.9	17.9 ± 0.6	4.26	1.01	71.7 ± 3.8	19.4 ± 1.0	3.70	0.84
140 Ru	68.1 ± 3.6	16.9 ± 1.4	4.03	0.98	71.1 ± 3.9	16.2 ± 1.0	4.39	1.09	58.1 ± 4.6	17.2 ± 1.4	3.38	0.82
99 R	67.3 ± 2.1	14.3 ± 0.5	4.71	1.25	73.8 ± 2.1	15.3 ± 0.9	4.82	1.23	70.3 ± 2.6	18.0 ± 1.8	3.91	0.92
1103 P	64.5 ± 2.1	15.7 ± 0.8	4.11	1.04	69.4 ± 5.5	15.4 ± 1.0	4.51	1.15	55.4 ± 2.6	18.6 ± 1.9	2.98	0.69
216-3 Cl	58.5 ± 2.3	12.9 ± 1.2	4.53	1.26	74.0 ± 3.8	13.0 ± 0.3	5.69	1.58	60.0 ± 4.3	15.0 ± 1.2	4.00	1.03
161-49 C	—	—			76.5 ± 5.3	15.9 ± 0.3	4.81	1.21	76.1 ± 2.0	18.1 ± 1.4	4.20	0.99

1) 11 years.
2) 8 years.
3) Y = Yield, P = Pruning weight.

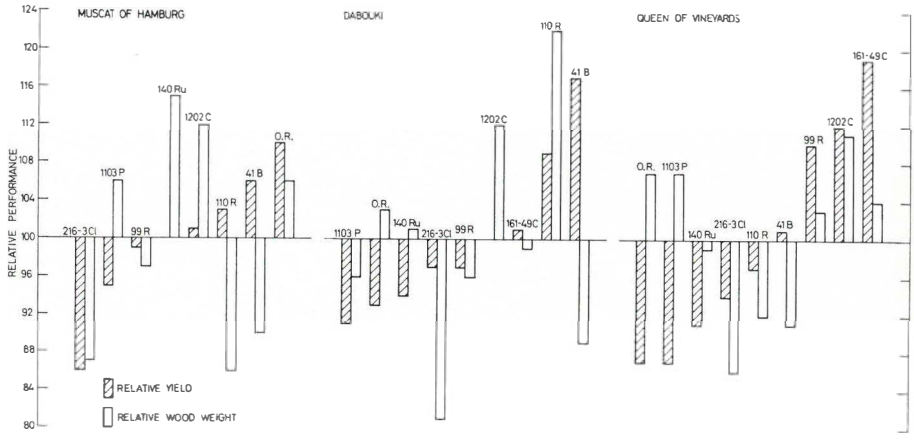

Fig. 1: Relative cumulative yield and vigor of three varieties on nine rootstocks. 100 on vertical axis = average value for all rootstock combinations in a year.

Fig. 1 illustrates the relative performance, as regards yield and vigor, of the three varieties on the different rootstocks. In the case of Muscat on 216-3, low vigor is associated with low relative yield, but with Muscat on 41 B and 110 R, low vigor is associated with above-average yields. Higher-than-average yields associated with vigor are found with Queen of the Vineyards on 99 R, 1202 and 161-49 and with Dabouki on 110 R. In the case of 41 B, above-average yields are associated with below-average vigor, particularly with Dabouki.

Relative vigor and relative yield of the three varieties throughout the bearing age are illustrated in Fig. 2. As to vigour, with some rootstocks, a relative ascending tendency was observed, like with Muscat on 1202 C, 140 Ru and 1103 P, while vigor declined with age on 41 B and 99 R. A longer period of experimentation seems advisable for additional study of vigor performance in the aforementioned combinations (Muscat on 1202 C, 140 Ru, 1103 P).

Queen of the Vineyards showed a similar relative increase in vigor with 1103 P and 140 Ru and to a lesser extent with 110 R, while own-root plants, 41 B and 216-3 exhibited a relatively sharp decline in vigor with age compared with other rootstocks. From the curves, however, it appears that while yields on own-root varieties increased with age, they decreased with Queen of the Vineyards on 41 B and 216-3 Cl. With Dabouki, a local variety of oriental origin with a different response to rootstocks, no such clear-cut trends were found. Some increase in vigor on 140 Ru with this variety was noted, with a large relative decrease on the own-root vines. No definite trends regarding change with age, in the relative order of bearing on different rootstocks, could be discerned, except for some decline in relative yield on 161-49.

Effect of rootstock upon fruit characteristics and composition

Bunch and berry weight, degree of compactness, TSS and acidity content on different rootstocks, were determined on the same date (Table 3). Average bunch and berry weight were, on the whole, not appreciably influenced by rootstock. 1103 gave the highest average bunch weight with Queen of the Vineyards. However, the values obtained showed a significant difference when compared with the other root-

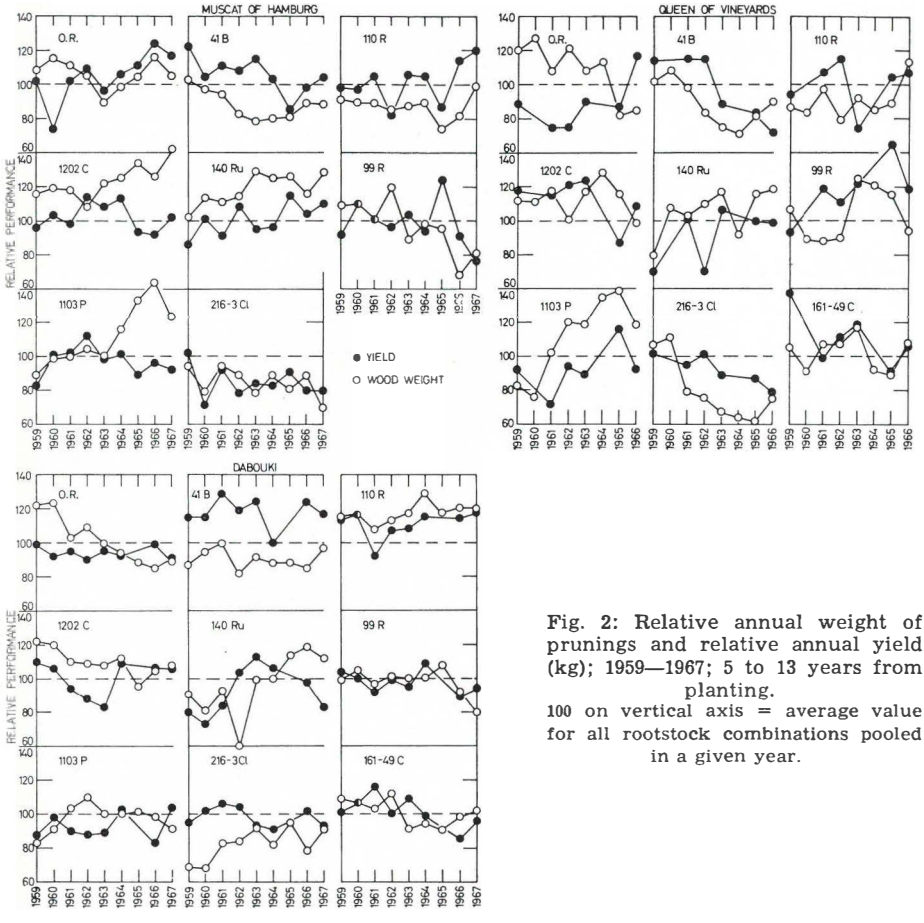

Fig. 2: Relative annual weight of prunings and relative annual yield (kg); 1959—1967; 5 to 13 years from planting.
100 on vertical axis = average value for all rootstock combinations pooled in a given year.

stocks in only two out of eight rootstocks. Lowest bunch weight was found with 41 B, while the same rootstock gave the heaviest bunches with Dabouki. 140 Ru and 110 R gave the heaviest bunches with Muscat. Differences in berry weight were generally small, except with Queen of the Vineyards on 99 R (larger berry weight).

Differences in compactness were also small. Own rooted Muscat of Hamburg had the most compact bunches.

Own-root varieties had a somewhat higher TSS/acid ratio with Dabouki and Muscat. These differences, generally associated with a relatively higher-than-average TSS content, were not found to be statistically significant.

Dabouki and Queen of the Vineyards had a high relative acid content and a below-average TSS on 1202. With Dabouki, even the lower TSS/acid ratios (26.52, 26.75) would still rate high as to palatability. With the relatively early maturing Queen of the Vineyards, even small differences in TSS and TSS/acid ratios are of greater significance.

Relative vigor of stock, scion and bud union

Table 4 gives the scion and rootstock circumference of two varieties included in this study. No significant overgrowth of either scion or rootstock was noted with

Table 3

The effect of 9 rootstocks on maturation and bunch characteristics[1]) of 3 *V. vinifera* varieties

Rootstock	Weight		Compactness[2])	Color[3])	TSS	Acid	TSS/Acid
	Bunch	Berry					
	g	g	degree	degree	%	mg/100 ml	ratio
			Muscat of Hamburg				
Own rooted	360^{b4})	3.4^{b}	3.2^{a}	2.3^{b}	16.2	.636	25.47
41 B	374^{ab}	3.6^{ab}	2.7^{b}	2.4^{b}	15.7	.655	23.97
110 R	401^{a}	3.5^{ab}	2.7^{b}	2.3^{b}	16.0	.654	24.46
1202 C	391^{ab}	3.9^{a}	2.7^{b}	2.3^{b}	15.8	.651	24.27
140 Ru	404^{a}	3.8^{ab}	2.8^{ab}	2.3^{b}	16.3	.685	23.80
99 R	370^{ab}	3.4^{b}	2.7^{b}	2.3^{b}	15.8	.644	24.53
1103 P	359^{b}	3.6^{ab}	2.9^{ab}	2.4^{b}	16.1	.665	24.21
216-3 Cl	346^{b}	3.5^{ab}	3.0^{ab}	2.6^{b}	15.8	.696	22.70
161-49 C	—	—	—		—	—	
Significance	5%	5%	5%	5%	N.S.	N.S.	N.S.
			Dabouki				
Own rooted	585^{b}	5.7	2.7	—	15.5	.496	31.25
41 B	633^{a}	5.7	2.6	—	15.0	.513	29.24
110 R	557^{b}	5.6	2.6	—	15.3	.577	26.52
1202 C	570^{b}	5.7	2.4	—	14.9	.557	26.75
140 Ru	591^{b}	5.6	2.6	—	15.2	.521	29.17
99 R	572^{b}	5.7	2.7	—	15.2	.501	30.34
1103 P	557^{b}	5.5	2.7	—	15.4	.521	29.56
216-3 Cl	601^{ab}	5.7	2.6	—	15.9	.476	33.40
161-49 C	545^{b}	5.7	2.7	—	15.4	.514	29.96
Significance	5%	N.S.	N.S.	—	N.S.	N.S.	N.S.
			Queen of Vineyards				
Own rooted	454^{b}	4.4^{b}	2.1	—	12.1^{ab}	.636	19.34^{ab}
41 B	445^{b}	4.1^{b}	2.3	—	12.3^{a}	.656	18.14^{ab}
110 R	483^{ab}	4.4^{b}	2.3	—	11.9^{b}	.601	20.30^{a}
1202 C	548^{ab}	4.3^{b}	2.1	—	12.2^{a}	.663	17.50^{c}
140 Ru	545^{ab}	4.3^{b}	2.0	—	11.6^{b}	.650	17.69^{bc}
99 R	536^{ab}	4.8^{a}	2.3	—	11.5^{b}	.642	18.38^{b}
1103 P	580^{a}	4.2^{b}	2.1	—	12.1^{ab}	.594	20.37^{a}
216-3 Cl	485^{ab}	4.2^{b}	2.2	—	11.8^{b}	.639	18.62^{b}
161-49 C	530^{ab}	4.3^{b}	2.0	—	11.9^{b}	.632	19.15^{ab}
Significance	5%	5%	N.S.	—	5%	N.S.	

[1]) Average for four years.
[2]) Rating 1—5.
[3]) Rating 1—3.
[4]) Values followed by the same letter in any one column are not statistically different at the 5% level.

Table 4

Scion and rootstock circumference[1]) 13 years after planting

Rootstock	Muscat of Hamburg			Dabouki		
	Top	Rootstock	Top/ Rootstock	Top	Rootstock	Top/ Rootstock
	cm	cm	ratio	cm	cm	ratio
41 B	14.5	15.8	.92	18.1	14.0	1.29
110 R	15.2	14.4	1.06	19.5	15.8	1.23
1202 C	14.3	17.6	.81	18.0	16.5	1.12
140 Ru	14.5	15.8	.92	19.0	15.0	1.27
99 R	15.7	17.9	.88	19.1	16.7	1.14
1103 P	15.3	16.0	.96	18.4	14.8	1.24
216-3 Cl	14.8	15.6	.95	18.8	14.4	1.31
161-49 C	—	—	—	18.0	13.5	1.33

[1]) Scion measured 10 cm above, stock measured 10 cm below graft union.

Muscat of Hamburg in any of the combinations. When Dabouki is grafted, an overgrowth of scion as compared with rootstock generally takes place (13). A noticeable overgrowth was found, especially on 161-49 C, 216-3 Cl, 41 B and 140 R, but also with 140 Ru and 110 R. While Dabouki on 41 B and 216-3 showed considerable overgrowth of scion, high top/root ratios (Table 4) and also a relatively low cumulative weight of prunings (Table 2), Dabouki on 110 R — a combination which also showed a considerable overgrowth of scion — had the highest cumulative weight of prunings. Cumulative pruning wood seems to give a more dependable measure of vigor than the ratio of top/rootstock circumference.

Discussion

The adaptation of *V. berlandieri*-cross rootstocks to moderately calcareous soil and arid conditions, has been confirmed in this study. Likewise, 41 B and 110 R have been found to rank among the best all-purpose rootstocks for table grape varieties.

Galet (9) and Cuende (8) recorded the good performance of these rootstocks under somewhat analogous conditions.

Only one *V. riparia*-cross rootstock, 161-49 C, considered generally well adapted to arid, calcareous soil conditions, was used. No signs of "folletage" observed on this rootstock in some situations in North Africa (14, 17), have been noticed by us. The performance of this rootstock with Queen of the Vineyards and Dabouki was highly satisfactory. Boubals and Pistre (4) found, in France, that another *V. berlandieri* × *V. riparia* rootstock, SO4, gave the highest yield with several vine varieties.

At the same time, *Solonis* × *V. rupestris* 216-3 Cl, known to perform well under somewhat saline soil conditions (9, 13) with certain varieties in the more rainy, northern part of Israel (2), was rather disappointing in yield and vigor. This may have been due to the very low winter precipitation. Its weak adaptation to dry soils has been noted also by Galet (9).

This is the first long-term trial in Israel on the relative performance of the two Sicilian *V. berlandieri* × *V. rupestris* rootstocks — 140 R, 1103 P — compared

with 110 R and 99 R, also *V. berlandieri* × *V. rupestris* clones. While the yield performance of 110 R was more satisfactory than that of 140 R and 1103 P, the latter two rootstocks and 1202 C showed a pronounced relative increase in vigor with age as compared with other rootstocks. This might indicate a possible trend toward the attainment of maximum cropping at a later age. Grafting with the three rootstocks mentioned also had a consistently lower yield/wood ratio, and might have possibly benefited from a longer pruning than the uniform pruning accorded all vines in the experiment. Chasselas × *V. berlandieri* 41 B, which had the highest yield/wood ratio with all three scion varieties, showed at the same time a pronounced decline in vigor with age. These facts point to the possibility of reaching a different evaluation on the relative merits and performance of different rootstocks, had the experiment been continued for a longer period. Early decline on 41 B has been reported under our conditions (13), and in N. Africa (21), but Constantinescu (6) found in Rumania that vines grafted onto 41 B had the longest productive life compared with other rootstocks. A different annual yield/wood ratio might, however, be involved.

Of particular interest is the relative performance of own-root *V. vinifera* cultivars. Relative yields were high with own rooted Muscat of Hamburg, about average with Dabouki, and very poor with Queen of the Vineyards. This is in accordance with much earlier conclusions (18) that own-root *V. vinifera* cultivars differ in their relative performance, according to variety. Performance of own rooted Perlette and Queen of the Vineyards in the desert near Eilat was disappointing[1]). On the other hand, own rooted Semillon and Grenache gave good to very good results in a trial performed at Gilat[2]) in the vicinity of our experimental plots. Similarly, in Austria (15) own-root vines of Müller-Thurgau excelled by earlier and bigger yields in comparison with other rootstocks. Results with early ripening table varieties seem to be more disappointing than the relative performance of later maturing ones and wine grapes.

Ungrafted *V. vinifera* cultivars may also react differently from grafted vines, as regards fruit setting, color and other characteristics (18). This has not been borne out under the conditions of our experiment. In a rootstocks experiment at Beit HaShitta[3]), own rooted Madeleine Oberlin plants had the highest vigor, and at the same time a significantly later period of ripening of the fruit. Relative performance of own-root *V. vinifera* cultivars compared with other rootstocks would also depend on the virological status of the plant material employed.

In our experiment no correlation was found between the vigor of the variety (as evidenced by weight of prunings) and the yield on different rootstocks. Hegedüs and Iso (11) likewise found that while plant vigor depended greatly upon rootstock, frequently no relationship was found between vigor and productivity. Hidalgo and Candela (12), however, found a good correlation between vigor and yield, especially with rootstocks of relatively high vigor. Some of our stionic combinations, like Queen of the Vineyards on 99 R, 1202 C and 161-49 C, and Dabouki on 110 R, gave satisfactory results as to both yield and vigor. Yet, combinations on 41 B confirmed that this rootstock, while conducive to good cropping, does not confer adequate vigor.

Relative performance of rootstocks also varied considerably, according to the particular stionic combination employed. While no one rootstock gave the best

[1]) Lavee, S.: Unpublished results.
[2]) Manuscript in preparation by authors.
[3]) R. M. Samish and Spiegel-Roy, P.: Unpublished results.

results with all three varieties employed, 41 B and 110 R, and to a lesser extent 161-49, gave very satisfactory relative yields with two out of the three varieties tested. However, results have to be analyzed specifically for each variety.

Different rootstocks had only a slight and rarely significant effect on time of ripening, berry weight and bunch quality or color. Blaha (3) reports lack of influence of rootstock on the sugar content of grapes. While Mottard *et al.* (16) and Galet (9) report earlier ripening on 41 B and later ripening on 110 R and 99 R, this has not been found under our conditions (13, 20) nor in the present experiment.

A higher than average TSS content of fruit on own-root *V. vinifera* varieties was found in Portugal[1]). In the present experiment, fruit of own rooted Dabouki, as well as Muscat of Hamburg, showed on the same date somewhat higher TSS values and wider TSS/acid ratios than fruit from other rootstocks.

Advanced maturity would be of much importance, mainly in early varieties, e. g. Queen of the Vineyards. The relatively narrow TSS/acid ratio found with Queen of the Vineyards on 1202 points to a later maturity on this rootstock, in our case. However, in a warmer winter climate, 1202 was often conducive to earlier ripening with Queen of the Vineyards (20).

The uniform treatment and pruning and the relatively small differences in yield between combinations did not enhance significant variation in berry and bunch quality. Size of yield is known to affect fruit characteristics and composition of the grape to a greater extent than does the rootstock (5, 22, 23).

Summary

The performance of the table grape varieties Queen of the Vineyards, Muscat of Hamburg and Dabouki on eight different rootstocks, was studied in the arid Negev, on a loess soil under irrigation.

The highest yields (nine years of bearing) from Queen of the Vineyards were recorded on 161-49, followed by 1202 and 99 R; from Muscat of Hamburg on own-root plants, 41 B and 110 R; from Dabouki on 41 B, 110 R and 161-49.

Maximum vigor in Queen of the Vineyards was obtained on 1202, followed by own-root plants and 1103; in Muscat of Hamburg, on 140 R and 1202; in Dabouki, on 110 R and 1202.

Highest relative fruitfulness (ratio of total crop per total weight of prunings) of Queen of the Vineyards was found on 161-49, followed by 41 B and 216-3; of Muscat of Hamburg, on 110 R and 41 B; of Dabouki, on 41 B and 216-3.

No correlation was noted between the ranking of stionic combinations as to vigor and their ranking as yielders. There was a marked tendency toward decreased vigor with age, except on 140 with all three varieties, on 1103 and 1202 with Muscat, on 216—3 with Dabouki, and on 1103 with Queen of the Vineyards.

A comparatively large overgrowth in the Dabouki variety with some rootstocks did not impair performance.

Great variation was noted in the performance of different varieties of *V. vinifera* on their own roots; high relative yields were obtained with Muscat of Hamburg, and low yield with Queen of the Vineyards. Only small differences were found in quality, cluster weight and berry weight on different rootstocks.

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[1]) Personal communication by Prof. L. C. da Costa (1963).

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Dr. P. SPIEGEL-ROY
The Volcani Institute of
Agricultural Research
P.O.B. 6, Bet Dagan
Israel