

PLANT SCIENCES

RESPONSE OF 'BONITA' AND 'VENTURA' PEACH CULTIVARS ON VARIOUS PEACH AND APRICOT SEEDLING ROOTSTOCKS IN AN ARID ENVIRONMENT

By

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'Bonita' and 'Ventura' peach cultivars grown for a nine-year period on five peach rootstocks and on 'Klabi' apricot were most productive on 'Baladi' and 'S-37' peach rootstocks. 'Klabi' apricot performed better with 'Ventura' than with 'Bonita'. The greatest vigor was achieved on 'S-37', and the least on 'Elberta' as a rootstock. All peach rootstocks were susceptible to root-knot nematodes (*Meloidogyne* sp.), but 'Baladi' showed the greatest tolerance to nematode damage; 'Klabi' apricot was resistant to nematodes.

A comparison of ten peach cultivars on 'Baladi' peach and on 'Klabi' apricot revealed significant differences in yield in favor of 'Baladi' for three cultivars and in favor of 'Klabi' for one cultivar. 'Klabi' produced smaller trees than 'Baladi', but productivity per unit of trunk area was equal and productivity per unit of tree weight was higher for 'Klabi' than for 'Baladi'.

INTRODUCTION

Low-chilling peach (*Prunus persica*) cultivars perform well in the Negev, the southern part of Israel, with its mild winter climate. Soils in the eastern Negev are loessial, of aeolic origin, and well adapted to peach cultivation (6, 18).

Rootstock adaptation was considered of prime importance because of the relatively high lime content of the soil, the prevalence of nematodes, and the possible influence of the rootstock on fruit characteristics and ripening (1, 2).

The objective of this study was to find the most suitable rootstock for the peach in the northern Negev and similar arid environments. Some experiments have dealt with the relative performance of peach seedlings as rootstocks for the peach (3, 4, 7, 9, 17). Sensitivity to lime (5, 11, 17) and to nematode infestation (2, 4, 7, 13) is known to be high in most peach seedlings, but nematode-resistant peach rootstocks have been developed (8, 12, 15, 16, 19). The apricot has sometimes been used as a rootstock on

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account of its immunity to root-knot nematodes (6, 13), but affinity problems have arisen with this rootstock (4, 21).

MATERIALS AND METHODS

An orchard was planted in 1960 at the Gilat Experiment Station (northern Negev) in a loess soil with a typical composition of 2.4% coarse sand, 45-59% fine sand, 25-37% silt, 13-18% clay and 16-27% lime. The pH ranged from 7.2-8.1. Natural rainfall ranged from 200-300 mm and was supplemented with 600-700 m³ of irrigation water.

Two experimental designs were followed. In one, two peach cultivars, 'Bonita' and 'Ventura', grafted on six seedling rootstocks, were grown in randomized blocks of four trees in four replications for each cultivar-rootstock combination. The rootstocks used were 'Baladi' peach, a local peach seedling rootstock (6); 'S-37' peach, a nematode-resistant rootstock (12); 'Shalil' peach, a rootstock cultivar introduced from the U.S.A. and regarded previously as nematode resistant (19); 'Yellow Peach', a South African peach seedling rootstock (6); 'Elberta' peach seedlings; and 'Klabi', a local apricot rootstock known to be immune to root-knot nematodes (6). In the second experiment, ten peach cultivars, on two rootstocks, 'Baladi' peach and 'Klabi' apricot, were grown in fully randomized blocks of two trees in three replications for each cultivar-rootstock combination. The peach cultivars tested were '2 Star', '4 Star', 'Babcock', 'Redwing', 'C.O. Smith', 'Early Hiley', 'Hermosa', 'Lesley 204-7', 'Lesley 198-12' and 'July Elberta'.

Trees were spaced 5 × 6 m. The experiment was conducted for nine years and the data given here are from six yields, with the yield from each tree being recorded individually. A sample of 50 fruits per replication was selected at random for 4 years to evaluate fruit characters. Rootstock, scion and graft union circumference were measured; tree volume was estimated from the height and width dimensions. The entire above-ground part of the tree was weighed at the end of the experiment. Sensitivity to lime-induced iron chlorosis was estimated annually for each tree, according to an arbitrary 0-4 scale of increasing sensitivity.

RESULTS

Data on the performance of peach cultivars 'Ventura' and 'Bonita' on five peach rootstocks and on seedlings of the local 'Klabi' apricot, are given in Table 1. The two peach cultivars were most productive on 'Baladi' and 'S-37' rootstocks. 'Shalil' caused dieback even on young trees, before they came into bearing. 'Yellow Peach' was moderately productive, and the lowest yield was obtained on 'Elberta' seedlings. The 'Klabi' apricot was very productive with 'Ventura' and did not differ significantly from the best yielding peach rootstock, but had a lower yield with 'Bonita'.

TABLE 1
PERFORMANCE OF 'VENTURA' AND 'BONITA' PEACH CULTIVARS ON FIVE DIFFERENT ROOTSTOCKS

Cultivar	Rootstock	Cumulative six-year yield (kg)	Circumference ¹ (cm)			Trunk area (cm ²)	Tree weight ² (kg)	Tree height (m)	Tree width (m)	Yield/ trunk area ratio	Yield/ tree volume ratio	Chlorosis index ³
			Root- stock	Union	Scion							
Ventura	Baladi	366 ^a	77 ^{ab}	71 ^b	65 ^b	336 ^b	148 ^b	5.1 ^a	5.1 ^a	1.09	14.07	0.7
	S-37	333 ^a	84 ^a	79 ^a	72 ^a	412 ^a	221 ^a	4.7 ^a	5.5 ^a	0.81	12.88	0.8
	Yellow Peach	317 ^{ab}	73 ^b	73 ^{ab}	64 ^b	326 ^b	118 ^c	4.0 ^b	4.3 ^b	0.97	18.43	1.4
	Elberta	231 ^b	64 ^c	60 ^c	54 ^c	232 ^c	89 ^d	3.4 ^c	4.0 ^b	0.99	16.99	0.8
	Klabi	328 ^a	71 ^{bc}	75 ^a	64 ^b	326 ^b	121 ^{bc}	4.0 ^b	4.5 ^b	1.01	18.22	0.7
Bonita	Baladi	268 ^a	64 ^a	52 ^c	49 ^b	191 ^b	64 ^b	3.3	3.9 ^{ab}	1.40	20.82	1.1
	S-37	279 ^a	65 ^a	59 ^a	66 ^a	250 ^a	88 ^a	3.7	4.4 ^a	1.12	17.14	1.1
	Yellow Peach	262 ^a	63 ^{ab}	59 ^a	56 ^a	250 ^a	71 ^b	3.1	3.8 ^b	1.05	22.24	2.1
	Elberta	245 ^{ab}	61 ^{ab}	56 ^b	52 ^{ab}	215 ^{ab}	69 ^b	3.3	4.0 ^{ab}	1.14	18.56	1.5
	Klabi	217 ^b	59 ^b	61 ^a	52 ^{ab}	215 ^{ab}	60 ^b	3.1	3.6 ^b	1.01	19.44	1.1

Values followed by different letters within any column, differ statistically at the 5% level.

¹ 10 cm above union.

² All above-ground growth.

³ Scale ranging from 0 = no chlorosis to 4 = completely chlorotic.

'S-37' was the most vigorous rootstock for both peach cultivars. 'Baladi' was vigorous with 'Ventura' but less so with 'Bonita'; 'Yellow Peach' was moderately vigorous with both cultivars; 'Elberta' was the least vigorous peach rootstock. 'Klabi' was more vigorous with 'Ventura' than with 'Bonita'.

'Ventura' was generally the more productive and vigorous cultivar of the two, but 'Bonita' proved more productive than 'Ventura' on the basis of yield per trunk area and tree volume. The relatively greater productivity of smaller trees became evident also when the effect of rootstock was assessed for each cultivar separately. 'Yellow Peach' proved the most sensitive peach rootstock to lime-induced chlorosis, while 'Klabi' apricot was about equal to the best peach rootstocks in sensitivity. 'Bonita' generally showed more chlorosis than 'Ventura'.

The different rootstocks had no significant influence on fruit weight or firmness of fruit (Table 2), but the following trends could be observed: 'S-37' yielded the largest fruit, in spite of high yields; 'Klabi' had the firmest fruit, possibly indicating a somewhat later ripening date; and 'Yellow Peach' produced the smallest fruits.

TABLE 2
FRUIT WEIGHT AND FIRMNESS OF 'VENTURA' AND 'BONITA'
PEACH CULTIVARS ON FIVE DIFFERENT ROOTSTOCKS

(Average of 3 years of observations. Data for 'Ventura' are given in regular type; data for 'Bonita' are given in *italics*.)

Rootstock	Fruit weight (g)	Firmness suture (lbs/inch ²)	Opposite suture
Baladi	82	3.5	5.8
	96	11.7	11.4
S-37	83	5.6	10.5
	106	12.8	12.8
Yellow Peach	78	4.0	8.4
	90	11.6	11.6
Elberta	81	5.4	8.2
	103	13.0	13.1
Klabi	81	6.1	8.9
	105	16.2	16.3

As the orchard was attacked by the root-knot nematode *Meloidogyne* sp., it was of interest to observe the differential response of rootstock regarding tolerance and survival. All peach rootstocks were found to be heavily infested but showed differing degrees of resistance, as judged by field performance (Fig. 1). 'Baladi' was most resistant, with the

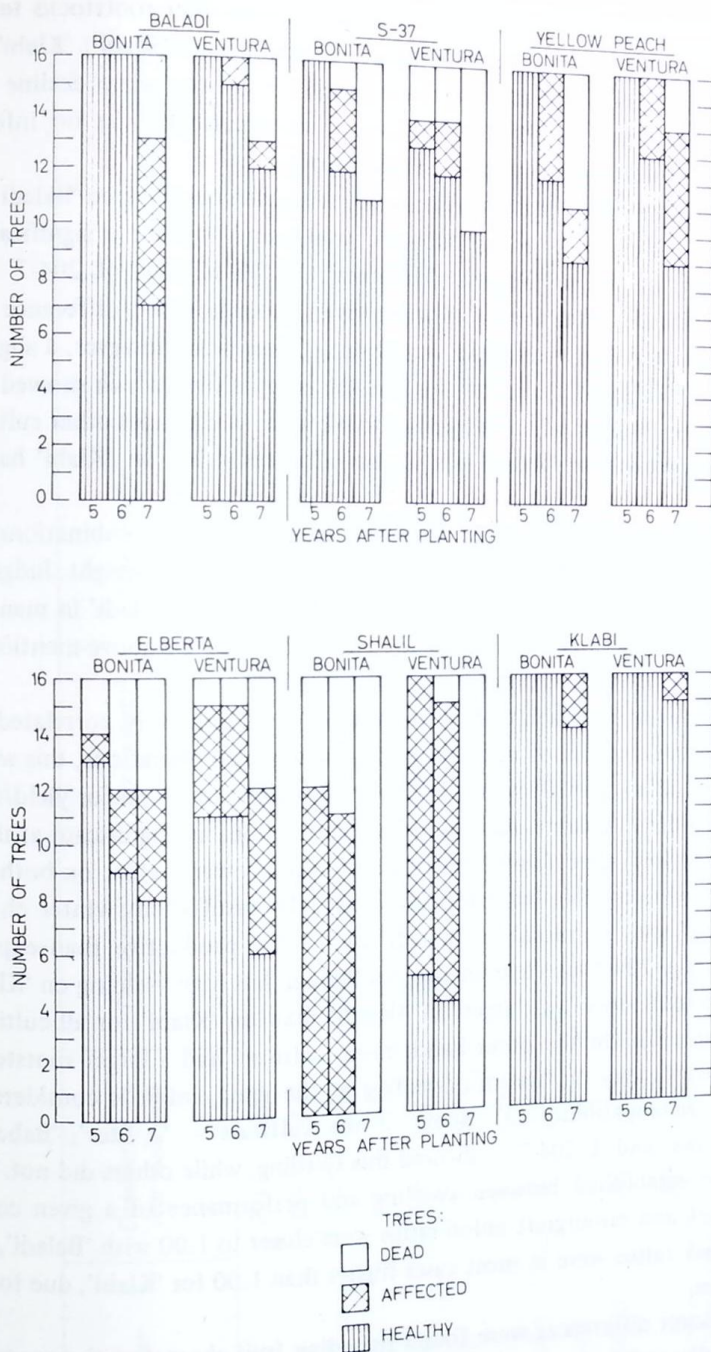


Fig. 1. Progressive damage by *Meloidogyne* sp. nematodes to 'Ventura' and 'Bonita' cultivars on five peach rootstocks and 'Klabi' apricot during three successive years.

symptoms of decline appearing at a later age than in the other rootstocks tested. 'S-37' was second best, followed by 'Yellow Peach', 'Elberta' and 'Shalil'; 'Klabi' apricot, a rootstock known to be immune to nematode injury, showed some decline symptoms. These may have been due to rootstock-scion incompatibility, as no infestation by *Meloidogyne* was found on the roots of this rootstock.

In the study comparing the performance of ten peach cultivars on 'Baladi' peach and 'Klabi' apricot seedling rootstocks, 'Babcock' was found to have a significantly higher cumulative yield on 'Klabi', whereas 'Hermosa', 'L.198-12' and 'L.204-7' were more productive on 'Baladi'. With the six other cultivars, no significant difference in yielding capacity between the two rootstocks was found. There was, however, a slight trend in favor of 'Baladi' (Table 3). 'Babcock' was also the only cultivar which showed more vigor on 'Klabi' than on 'Baladi' when judged by trunk area, while most other cultivars tested indicated better growth on 'Baladi'. In almost all cases, trees on 'Klabi' had a smaller bearing area.

The relative productivity of the different scion-rootstock combinations was calculated on the basis of yield per trunk area as well as of yield per tree weight. Judging by these parameters, 'Klabi' appeared to have a higher potential than 'Baladi' in many combinations. These differences were significant for one or both of the above-mentioned criteria with 'Babcock', 'Redwing', 'Hermosa' and 'L. 198-12'.

The productivity of peach trees is considered to be positively correlated with vigor and size (1). In our comparison of all the scion-rootstock combinations, this was found to hold true. Correlations ($n=20$) were 0.64 for yield/trunk area, 0.56 for yield/tree weight, and 0.50 for yield/tree volume. Although these correlations are significant at the 1% level, important exceptions were found. 'Early Hiley' was a lower yielder on both rootstocks although very vigorous; this was probably caused by insufficient winter chilling. 'Babcock' on 'Klabi' and 'Hermosa' on 'Baladi' were more productive than expected from their vigor. 'Lesley 204-7' was low yielding on 'Baladi' but high yielding on 'Klabi'.

Trunk circumference was larger on 'Baladi' than on 'Klabi' for all cultivars except 'Babcock' (Table 4). On the other hand, more cultivars had a larger rootstock circumference on 'Klabi' than on 'Baladi'. Swelling at the graft union is considered to be an indicator for incompatibility (3). Some of the cultivars — '2 Star', 'Babcock', 'C.O. Smith', 'Hermosa' and 'L.204-7' — showed this swelling, while others did not. No correlation could be established between swelling and performance of a given combination. Scion/rootstock and scion/graft union ratios were closer to 1.00 with 'Baladi', while graft union/rootstock ratios were in most cases higher than 1.00 for 'Klabi', due to swelling at the graft union.

No significant differences were found regarding fruit characteristics examined for all scion-rootstock combinations (Table 5). However, TSS was consistently higher and total acid content was always lower with 'Klabi' as rootstock. Fruit on 'Klabi' showed also a tendency toward greater firmness at the same picking date.

TABLE 3
COMPARISON OF THE PERFORMANCE OF TEN PEACH CULTIVARS ON 'BALADI' PEACH (B)
AND 'KLABI' APRICOT (K) ROOTSTOCKS

Cultivar	Cumulative six-year yield (kg)		Trunk area ¹ (cm)		Tree weight ² (kg)		Tree volume ³ (m ³)		Yield per cm ² trunk area (kg)		Yield per kg tree weight (kg)	
	B	K	B	K	B	K	B	K	B	K	B	K
2 Star	201	183	179	161	67	62	15.0	16.2	1.12	1.13	3.01	2.95
4 Star	249	219	301	259	92	95	15.5	19.0	0.83	0.84	2.71	2.30
Babcock	396 ^a	495	296	484	142	135	21.9	21.2	1.34	1.02	2.78	3.66
Redwing	229	180	241	137	91	45	16.3	10.4	0.95	1.31	2.51	4.04
C.O. Smith	358	324	302	270	128	103	22.6	19.4	1.19	1.20	2.80	3.15
Early Hiley	237	225	431	379	188	132	29.1	21.0	0.55	0.59	1.26	1.70
Hermosa	264	180	123	121	39	34	8.1	7.8	2.15	1.48	6.86	5.28
Lesley 204-7	332	277	323	237	146	94	27.5	18.9	1.03	1.17	2.28	2.95
July Elberta	191	173	221	204	85	66	14.4	13.1	0.87	0.85	2.25	2.60
Lesley 198-12	290	257	265	166	96	47	18.6	9.6	1.09	1.54	3.02	5.43
Average	274	251	268	242	107	81	18.9	15.7	1.11	1.11	2.95	3.41

¹ 10 cm above union.

² All above-ground growth.

³ Calculated from height × width.

^a Italicized pairs of figures differ significantly at the 5% level.

TABLE 4
CIRCUMFERENCE OF TRUNK, ROOTSTOCK AND GRAFT UNION, AND THEIR RATIOS,
OF TEN CULTIVARS ON 'BALADI' PEACH (B) AND 'KLABI' APRICOT (K) ROOTSTOCKS

Cultivar	Circumference (cm)						Ratio of					
	Trunk		Union		Rootstock		Trunk/Rootstock		Trunk/Union		Union/Rootstock	
	B	K	B	K	B	K	B	K	B	K	B	K
2 Star	47.5	45.0	59.3	72.5	66.2	73.0	.72	.62	.80	.62	.90	.99
4 Star	61.5	57.0	68.5	68.0	69.5	68.0	.88	.84	.90	.84	.99	1.00
Babcock	61.0 ^a	78.0	67.7	102.0	72.8	95.0	.84	.82	.90	.76	.93	1.07
Redwing	55.0	41.5	67.3	64.0	74.0	55.0	.74	.75	.82	.65	.91	1.16
C.O. Smith	61.6	58.3	69.3	87.3	73.0	85.0	.84	.69	.89	.67	.95	1.03
Early Hiley	73.6	69.0	80.3	83.6	91.3	76.6	.81	.90	.92	.83	.88	1.09
Hermosa	39.3	39.0	50.5	76.0	50.8	68.0	.77	.57	.78	.51	.99	1.12
Lesley 204-7	63.7	54.5	69.3	103.5	75.0	103.0	.85	.65	.92	.83	.92	1.00
July Elberta	52.7	50.7	57.3	63.7	66.0	60.0	.80	.85	.92	.80	.87	1.06
Lesley 198-12	57.7	45.7	66.0	61.0	71.0	55.7	.80	.82	.87	.75	.94	1.10
Average	57.4	53.9	65.6	78.2	71.0	73.9	.81	.75	.87	.73	.93	1.06

^a Italicized pairs of figures differ significantly at the 5% level.

TABLE 5
EFFECT OF 'BALADI' PEACH (B) AND 'KLABI' APRICOT (K) ROOTSTOCKS
ON FRUIT CHARACTERISTICS

Cultivar	Fruit weight (g)		TSS		Acid		Firmness suture		Opposite suture	
	B	K	B	K	B	K	B	K	B	K
2 Star	69	70	10.1	10.3	10.7	9.9	7.5	8.4	10.3	11.3
4 Star	81	79	9.5	9.8	8.3	8.3	6.8	5.2	8.9	7.1
Babcock	70	78	10.7	10.5	3.5	3.0	8.7	8.1	10.7	14.2
Redwing	76	67	11.0	12.2	4.0	3.7	5.2	4.3	6.7	7.2
C.O. Smith	89	91	10.6	11.5	3.2	3.0	2.6	3.4	3.0	6.4
Early Hiley	111	118	8.7	9.2	2.8	1.8	7.5	6.0	11.8	10.7
Hermosa	82	90	11.4	12.3	3.7	5.1	13.2	12.5	12.0	13.5
L. 204-7	102	107	12.2	12.2	8.2	7.6	7.0	9.4	8.2	9.5
July Elberta	123 ^a	98	7.2	8.2	6.3	7.8	1.3	2.4	1.2	2.3
L. 198-12	114	98	12.1	13.0	7.2	6.7	11.4	7.3	10.7	8.1
Average	92	90	10.3	10.9	5.8	5.5	7.1	6.7	8.4	9.0

^a The italicized pair of figures differs significantly at the 5% level.

DISCUSSION

Although peach seed is the most common source of rootstocks for peach cultivars, few comparisons have been made of the relative value of different varieties as a seed source. More uniform seedlings can be obtained with kleistogamic varieties (11, 17), and probably also with seed obtained from solid blocks of plantings, and possibly from F₁ of inter-specific hybrids (10).

In the present experiment we were concerned mainly with conditions of a fairly calcareous soil, nematode infestation, and a mild winter environment. While such conditions are typical for the Negev, similar environments are encountered in other warm peach-growing areas of the world (16).

A positive correlation has been established in our experiment between tree size and yield. This corroborates previous observations (2, 20) and can be explained on the basis of the bearing habit of the peach and its tendency to annual cropping.

However, as of late, research on rootstocks has focused attention on the possibilities of the small, *i.e.*, size-controlled tree (19), and especially on those trees with a high theoretical productivity potential. This is more often assessed by the ratio of total cumulative yield to unit of trunk area or circumference. High productivity per surface area of such a combination is expected on the basis of a narrower than usual spacing of trees. On such a basis, both 'Klabi' apricot and 'Baladi' peach seem promising as rootstocks, especially for certain cultivars. 'Hermosa' on 'Baladi' was outstanding in total yield per trunk area.

'Baladi' peach and 'Klabi' apricot, local varieties with a very low chilling requirement, manifested the best adaptation to the soil conditions and nematode infestation of all the rootstocks tested. These two rootstocks had also, along with 'S-37' seedlings, a high degree of resistance or tolerance to lime-induced chlorosis.

While some cultivars performed better on 'Baladi' than on 'Klabi' rootstock, the average overall performance of 'Klabi' came fairly close to that of 'Baladi'. An interesting point is the much smaller tree weight of trees on 'Klabi' as compared with those on 'Baladi', with combinations having a similar trunk circumference on both rootstocks.

The sometimes very marked swelling at the graft union found with 'Klabi' apricot, and to a smaller degree with 'Baladi', was not a sign of an unsuitable stionic combination in the present experiment, although in many cases the trees were of smaller than average size.

Of the peach rootstocks tested 'S-37' was the most vigorous and, along with 'Baladi', the most productive. Resistance to *Meloidogyne incognita* has been reported for 'S-37' seedlings, along with little or variable resistance to *M. javanica* (7). In our experiment, performance and survival of peach on 'S-37' seedlings seemed to vary to a more appreciable extent than with other rootstocks, indicating a larger variability in response to soil conditions and nematode infestation. Although selection within 'S-37' progeny would offer a means of obtaining increased resistance also to *M. javanica*, these efforts have often been discouraged because of the high resistance in 'Nemaguard' peach seedlings and their widespread use (7). Nematode-resistant 'Nemaguard' and also certain peach x almond hybrids are now widely used in many irrigated arid soils as rootstocks for the peach. They tend, to a large extent, to supplant the use of and diminish interest in 'Elberta', 'Shalil' and even 'S-37' seedling rootstocks.

'S-37' performed much better than 'Shalil', in accordance with results obtained in California (2, 7). Results with 'Elberta' and especially 'Yellow Peach' seedlings were much better than with 'Shalil', and 'Yellow Peach' (low-chilling introduction from South Africa) gave results nearly comparable to 'S-37' and 'Baladi'. Trees of 'Bonita' on this rootstock were more vigorous than on 'Baladi' and equal to 'S-37' in vigor.

Results of lesser significance have been obtained on fruit quality and ripening on different rootstocks. Earlier ripening and larger fruit on apricot than on peach have been reported (14, 22), but no such effect on fruit size was found in our experiment. However, a definite trend toward earlier ripening and, at the same time, firmer fruit on apricot, has been established.

While most varieties included in our comparison trial of 'Baladi' and 'Klabi' rootstocks have a rather low chilling requirement, the 'Babcock' variety still significantly outyielded all varieties on both rootstocks.

The results presented show very significant differences between different peach seedling rootstocks. They also emphasize the value of local seedlings as a rootstock source, and draw attention to certain stionic combinations producing small trees with a remarkably high total yield per trunk area.

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