California Avocado Society 1974-75 Yearbook 58: 103-127

AVOCADO RESEARCH IN ISRAEL

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From November 11 to December 6, 1974, my wife and I had the good fortune to be in Israel as guests of the Volcani Center for agricultural research. This article summarizes my notes of subjects of interest and possible benefit to California avocado growers.

First a few general impressions:

THE COUNTRY. Israel is very small. Even though you know so ahead of time, only as you drive around to the farmed and the developed areas do you experience it.

Much of it is barren. This is what makes its small size so striking. I am not thinking here of the southern deserts, but of the "rock piles" that make up the heart of the country. Well, that would also describe southern California, and the marked similarity of the two regions is well known, so I should not have been surprised.

In recent years their government has planted thousands of these desolate acres to trees, chiefly pine. The result is ever-increasing aesthetic improvement; commercial usefulness is approaching. Couldn't we do the same? Apparently, natural dew supplements rainfall to an astonishing degree.

The country is a booming concern. I do not know of any other nation on earth that has made so much development and progress in so short a time. One example is agricultural research (including avocado studies). Recognizing the basic importance of agriculture, they are investing in research on a scale truly remarkable for so small and struggling a country. I would judge that Volcani has passed Riverside as the world's leading center for avocado research. And their work is of the very highest quality.

The country is in a state of perpetual siege. Soldiers and defense measures are everywhere. In the absence of military costs, what the nation could do both for itself and its neighbors (not forgetting avocado research advances of benefit world-wide, including southern California!) staggers the imagination. Which is one more reason that we should all hope for an early, permanent peace in this troubled area.

The people are remarkably hospitable. Wherever we went we were met with heart-warming kindnesses. Much of the fascination of Palestine is, of course, its history; we found our hosts highly sensitive to the emotional values for us Christians, and most helpful guides to the holy places of a faith they do not share. Whether you travel as part of an avocado tour, or with some other group, or as ordinary tourists, we would recommend it as a great place to visit.

THE AVOCADO INDUSTRY. Most Israeli avocados are grown along the Mediterranean

coast (Fig. 1A), from almost the border of Lebanon to scattered locations south of Tel Aviv. Some are planted in the Galilee region (Fig. 1B), chiefly in the upper Jordan Valley and on the west side of Lake Kinneret (also known as the Lake of Gennesaret, or the so-called Sea of Galilee).

Total acreage is about five thousand, or roughly 1/5 of California's. It is increasing steadily. Individual groves are relatively large, as part of a cooperative farm complex.

A major advantage of the Israeli industry is the apparent absence of root rot caused by *Phytophthora cinnamomi.* As a result, avocados are grown there on soils that would be considered far too poorly drained by California standards (Fig. 2A). Avocado roots evidently have inherent adaptation to an exceptionally wide range of soil types.

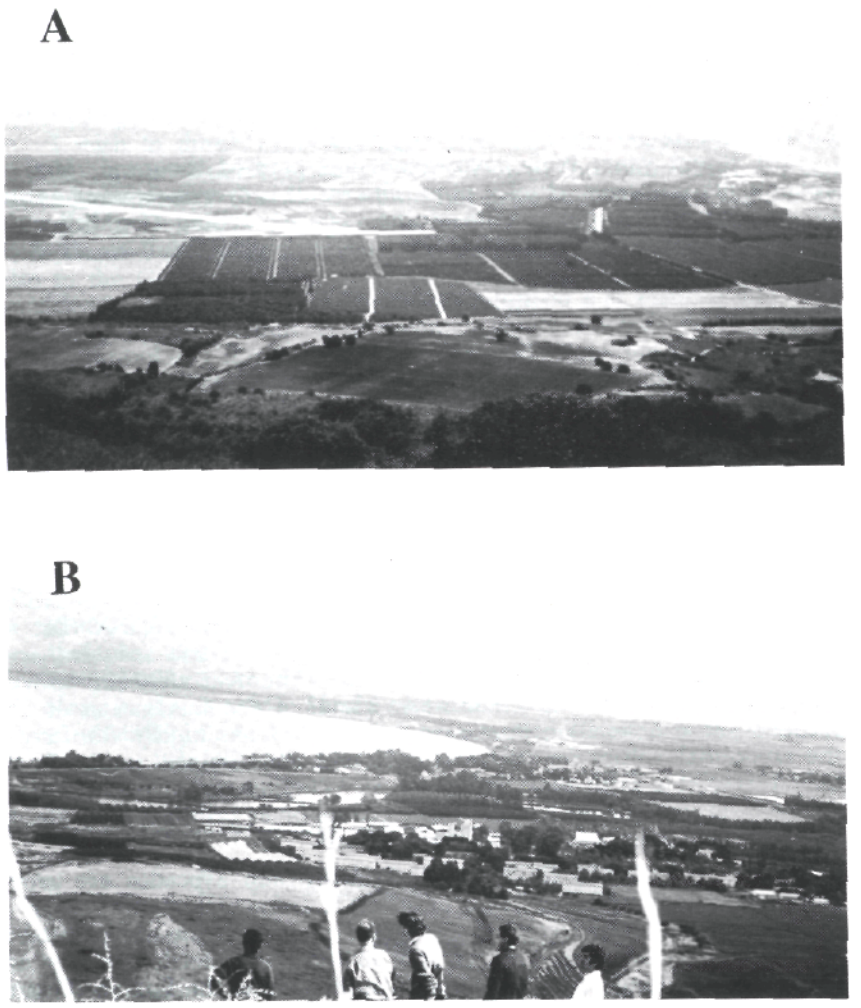

Figure 1. The major avocado growing regions of Israel. A, the coastal plains. This picture was taken looking south from the hills that adjoin the Lebanese border; note the Mediterranean breakers at the upper right. B, the Galilee region. The view shows the "Sea" of Galilee, with agricultural settlements in the foreground and the trans-Jordan hills beyond. Both the coastal and the Galilee plains present beautiful farming landscape, with a variety of crops. (Photographs by courtesy of Mr. Simon Zackai.)

Another major Israeli advantage is its climate. Winter weather is so mild that even the lowlands are practically frostless. Note in Fig. 2B the absence of any anti-frost safety measures. I do not recall seeing a single wind machine or heater in the country. Frosts have occurred, but too rarely to justify the expense of safeguards. Much of their avocado land is a true "Banana belt," with bananas also a commercial crop (Fig. 2C, D). For cultural reasons, the two are no longer as commonly planted together, but groves of both frequently adjoin.

Indeed, in this remarkable climate, apples—which have a climatic adaptation in the opposite direction from bananas—are also grown commercially close to avocados. I once noted adjoining groves of apple and Hass trees!

The mild climate is apparently reflected also in less chilling during the critical period of spring bloom. This is presumably the reason that their avocado yields average higher than ours. As in California, there are wide per acre production differences from grove to grove, and our best yields approximate theirs. Many cultural factors, of course, influence production; perhaps our superior groves have microclimatic advantages that approximate the typical Israeli situation.

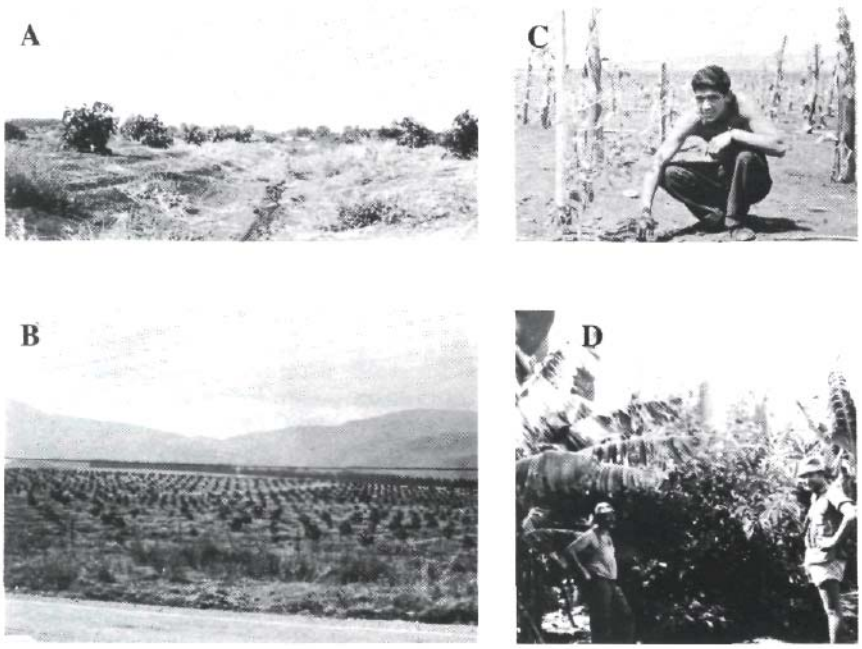

Figure 2. Some distinctive features of Israeli avocado production. A, since Phytophthora cinnamomi injury is unknown, avocados can be grown in soil so heavy that they must be planted on artificial ridges to prevent their suffocating. B, young avocados as in A. This also illustrates how they are nearly always grown on the lower lands instead of the hillsides as in California. Note the windbreak in the background. C, avocados and bananas being planted together, on a lighter soil. One of the reasons for lowland plantings is the usually frost-free Israeli climate, such that bananas are an important crop. D, the avocado trees are now coming into production; the bananas, having produced their quick returns, and beginning to crowd the avocados, will now be removed. (Photographs by courtesy of Mr. Simon Zackai.)

The interior Galilee area (Fig. 1B) is considerably hotter in summer, and apparently as a result it has more of a problem with undersized fruit. The Israeli size preference is

determined by their European market, primarily France. This preference has been evolving upward: "Nabal used to be too large—now Hass is too small." Mr. Jack Shepherd of Calavo had suggested to me an optimum range for California avocados of 7 ½ to 10 oz.; now an Israeli estimated 11 to 12 oz. to be the ideal size for their markets.

However, Professor Chanan Oppenheimer, sagacious pioneer of Israeli horticulture and "grand old man" of world subtropical fruits, is conjecturing that recession may lead to a reduction in the size of avocado fruits preferred by Europeans. These are extraordinarily uncertain times.

VARIETIES ("cultivars"). The discussions here and following are based partly on my own Israeli observations and partly on the opinions of authorities there. The word "authorities" should be interpreted broadly: Israeli avocado people maintain a stoutly democratic individualism. As many opinions are commonly expressed as there are options. Sweeping or inadequately documented assertions are promptly challenged. All this provides an excellent climate for ferreting out the precise truth—plus lively entertainment! But it does make it difficult at times to arrive at a clear concensus. Unless I quote someone, therefore, my statements had best be understood as my own judgments.

Nothing is more subjective than relative flavor ratings. If concensus is impossible, a composite Israeli approximation (to which each person would want to make his own modifications) would be the following.

Excellent: Horshim

Very good: Benik, Ettinger, Fuerte, Hass

Good: Nabal, Netaim, Tova

Fair: Bacon, Reed

Poor: Zutano

HASS. Dr. Shmuel (Hebrew form of "Samuel") Gazit, the astute head of Volcani's Subtropical Horticulture department, considered Hass to be inherently the best avocado overall that they can grow; superior flavor over a remarkably long five or six months is only one of its virtues. We in California, where Hass is rapidly becoming the major variety, will find this expert opinion gratifying. Unfortunately for Israel, their particular markets do not like the Hass rough surface, black color, or small size.

Fruit size has been fairly adequate until the Hass tree is about six years of age, when it starts to decline. Pruning to produce larger fruits reduces total yield too much. However, Farm Advisor Benny Gefen has an interesting experimental grove on his own property. He has planted Hass trees just 13 feet by 16 feet apart. When they begin to crowd, they will be top- and side-pruned, much like lemons. He hopes to maintain good production by annual girdling. Girdling was begun when the trees were only two years of age, and will also help to keep the trees small. Small tree size will reduce picking costs. Anyone in California want to try it here?

Israeli experience parallels ours in that the Hass has proven unusually susceptible to various environmental injuries. Specifically, it is more susceptible to chlorosis, and,

apparently, in places to tipburn.

FUERTE. It and Hass have exceptionally long marketing seasons. However, Dr. Gazit finds the Fuerte period of outstanding flavor to be much shorter, perhaps two months. (I think that in California the two varieties are more similar. Fruit maturation is slower here, whereas in Israel the Fuerte matures when fall weather is still warm and the Hass matures about mid-winter. So the Hass season is lengthened by cool weather.) Dr. Gazit considers Fuerte to have optimum flavor at about 16% oil, with inferior taste below about 12% and above about 20%.

A problem with Fuertes in Israel is incomplete ripening: chunks of flesh fail to soften properly. It occurs in the layer next to the seed. It may involve up to 1/3 of the flesh volume. Dr. Gazit has found the region just above the seed to be most often affected, followed by the adjoining areas of the shoulder side, then the opposite side, and the region just below the seed is least often affected. He was unable to find any correlation with differences in calcium accumulation, although this correlation has been observed for ripening problems in other fruits. The condition is practically unknown in Nabal, rare in Hass, frequent also in Bonita, Corona, Irving and Rincón. It is more common in the large fruits resulting from light, crops, and especially later in the picking season. As many as 1/3 to 1/2 of a Fuerte pick have been affected.

Is this condition more common in California than I have thought?

As in California, irregular production is the major Fuerte weakness. While we have a few happy exceptions, Israel has a higher proportion of such. I saw one grove in the Jordan Valley that bore 3.000 Ibs./acre in this its third year. And an older grove, heavily loaded, that has averaged 16,000 Ibs/acre over the last years. Repeatedly, growers complained about crops that I considered good by our expectations. One man suggested that, unlike most varieties, Fuerte set may not be reduced by tree crowding.

Also as in California, the Fuerte is singularly prone to bud sporting. Definite strain differences provide one way that they are trying to increase Fuerte production. (A second way, also based on genetic differences, is by rootstock selection—discussed later in this article.) In one replicated experiment, using the same rootstock, one Fuerte scion has yielded more than four times as much as another, over the first four bearing years. Some promising Fuerte mutant selections: Weizel, Zriffin 55, De Bard, Rosh Hanikra #10. Each is a typical Fuerte, but with superior fruit yields. In the same category I would put Beit-Dagan 26/31; it has been described as a seedling, but I think that it is a Fuerte mutation, for higher yielding ability.

Each of these five has consistently set very good crops in at least one region of Israel. All, plus any others that show promise, should be tried in California before we "give up" on the great Fuerte.

In a different category are several other selections that have come out of Fuerte. These are highly distinctive in foliage and fruit. They are also very similar, if not identical. At least one reportedly appeared in a tree segment, like a typical mutation. But there are reasons for suspecting a virus: similarity of average expression of these distinctive types; considerable variation in expression among grafts from the same source, as occurs when virus concentration varies; the foliage deformation is typical of virus effects

in other plants. In addition to the severely puckered foliage, they differ in having fruits that, while of Fuerte season and quality, are more necked, much rougher-skinned, and smaller-seeded. And they set much better than ordinary Fuerte trees. Named selections of this type include Maabarot, Haya, Kabri, Kakun.

BACON. In Israel, it usually sets well (perhaps 12,000 Ibs/acre, on trees six years and older) but the fruits are small for their markets, have a short tree life, tend to break down in shipment, crack or soften at the blossom end, have a mediocre flavor.

ZUTANO. Is very little grown. I was told: "We think that a variety with such second rate flavor and general low quality does the industry more harm than good."

NABAL. All varieties mature earlier in Israel, and the later its season the greater the difference from California: Nabal matures about February there. Varieties usually bear better in Israel, and especially Nabal: it averages perhaps 16,000 Ibs/acre and is the best money-maker for some growers. (Wilson Popenoe, take a bow!) It alternates markedly, like Hass in both California and Israel. But, unlike Hass, Nabal alternation benefits fruit size, by bringing it down near optimum.

The round fruits seem to be no real handicap in their markets. But when early Fuertes from South Africa arrive on the European markets, the Israeli Nabal price slumps. Its seedlings make fine rootstocks on lighter soils where chlorosis is no problem. And as grafted trees it apparently does best on light soils (in contrast to Hass); moreover, fruit size is a little smaller on lighter soils.

Their experiences with minor California varieties, in brief:

ANAHEIM: Very poor quality; watery, bitter, short fruit life, flesh darkens and breaks down rapidly.

ARTURO: Very good earliness, quality, and production, But fruits too small.

BONITA: Seed germinates before it's mature.

CAMULOS: High quality, but poor set.

CORONA: Most trees good growers, fine set, Fuerte season, good fruit size. Seed germinates before maturity.

CREELMAN: Poor set.

EDRANOL: Much russet in Israel also. But fine set there.

IRVING: Small tree, which is a major advantage. Set to very good. High quality.

LAS POSAS: Good set, too small.

REED: Precocious, very good set (even without added bees, unlike other varieties). Mediocre taste; barely acceptable at 8-10% oil, fair when 10-15%, unacceptable over 15%.

REGINA: Very good set, fruit looks larger than California's to me.

SHEPHERD: Poor set, frost tender.

STEWART: Very good set and quality, but consistently and uniquely attacked by thrips.

TEAGUE *(UCR 14-11):* Remarkably long shelf life. Often huge trees with poor crops.

WURTZ: "Umbrella" trees with good set when young. Very late maturity. Poor keeper. Large seed.

UCR 1-1: Severe russeting and transverse cracking in Israel also. So it is not just our smog!

HASTON *(UCR 17-51):* Good set and does not alternate as in California. *Very* high quality, long tree storage.

UCR 18-3: Only fair set, many cukes. Discard.

ISRAELI VARIETIES:

ETTINGER. It is comparable to California's Bacon and Zutano, but with superior flavor and general quality. The tree is at least as cold hardy as Bacon. The tree is also tall and slim like our two chief early varieties. And as with ours, nipping the upright growing tips three or four times a season, from the beginning, has developed much better tree shape. I saw one interesting private grove where the branches on young Ettinger trees were being tied down horizontally, in the [unlikely?] hope of producing earlier set, as well as less erect trees. In only one grove was I given a long-range yield average: 13,000 Ibs/acre. In places it is now being planted for windbreaks, instead of cypress trees.

Because it is their earliest important variety, there is the temptation to pick it prematurely. Then it has been rubbery and, surprisingly, has had blackened fibrovascular bundles. I was given an interesting comparative flavor impression: at the beginning of its season, it is not as good as Fuerte already is (again reflecting the remarkable long Fuerte season). But its flavor develops rapidly and by full maturity it is distinctly better than Fuerte (which has not yet reached its prime). I sampled many Ettingers toward the end of its season and found them delicious—at least as good as my recollection of Fuerte or Hass, and definitely better than any Bacon or Zutano fruit that I have tasted.

The Ettinger was apparently first tried in California at U.C. Riverside. Here, we rejected it because of severe skin corking plus a large seed cavity. I wonder if that judgment were not overhasty. It would seem to merit a more thorough testing, in the better California avocado areas. Also, I am re-introducing budwood, on the chance that we happened to get an inferior mutant the first time. Its flower type is "B".

TOVA. This variety was discovered several years ago by genial Ephraim Slor (who has worked extensively with Prof. Oppenheimer in recent years). He found it, also Netaim and Horshim, in a search through some 5,000 Israeli windbreak seedlings. Its outstanding feature is productivity: apparently average crops of over 20,000 Ibs/acre can be expected. There is very little alternation. And the tree is small, for cheaper harvesting. Moreover, as a midseason fruit it could provide a replacement for much of the Fuerte period.

The fruit is attractive when it is picked, but develops severe skin blemishing as it softens. Although this darkening does not affect the flesh, the ripe fruit is quite ugly. This

is aggravated by even careful shipping and handling. Hopefully, especially since much of the degeneration is caused by the anthracnose *Colletotrichum* fungus in Israel, this will be of less concern in California. Also of less concern to California markets is the rather small size of fruits. But the tree is reportedly at least as cold tender as Hass, which is more serious for Californians, and especially disappointing in a variety that matures this early. Also, its marketing season is considerably shorter than that of Fuerte: it starts later and ends much sooner.

Much of the initial enthusiasm for Tova has evaporated. One opinion expressed was that its chief future is as a breeding parent, and a cross-pollinator (it is "A" flower type). Mr. Gefen now considers it a poor variety. Others still feel that anything with so remarkable yielding ability must have some commercial contribution to make. Time will tell. Certainly it must be tried in California.

HORSHIM. This second of Mr. Slor's discoveries is the opposite of the first: its productivity is suspect but fruit quality is superb (see the comparative ratings near the beginning of this section). The fruit that I tasted was not as flavorful as Ettinger, but the former was near the beginning of its season and the latter near the end. (For this and other reasons, there are commonly greater taste differences among fruits of a given variety than the average differences among varieties.)

Horshim production alternates sharply on individual trees. Production so far has not been too impressive, but the grafted trees are still young. They are usually quite vigorous, so girdling is being tried as a means of increasing the yields. It matures about with Tova but hangs much longer. "B" flower type.

Possibly Horshim will prove more valuable in California than Tova.

NETAIM. It could be the best of the three for us. To some degree it combines the virtues of the other two: each tree bears abundantly in alternate years, and fruit quality is high. It ships very well. It is attractive when ripe. Flavor was listed as "good" overall, on a par with Nabal, and some would rate it higher.

It sets so heavily in the "on" year that hand thinning has been practiced to maintain fruit size. A slightly lower set in California could still leave average yields at least as high as Hass and present us with a superior green summer fruit. It matures later than Hass. Cold hardiness appears to be at least equal to Hass. Its flower is of "B" type.

Several very new and promising selections will be described briefly. I did not see all of them and am indebted to Mr. Slor for descriptions.

EIN-VERED. This one I did see—its productivity is striking. It alternates very little and yields may even average with those of Tova. It is thought to be a Nabal seedling. Unfortunately for us, fruit size in Israel is about as large as Nabal, but its fruits are more advantageously pear-shaped. The tree is more spreading than Nabal and less subject to breakage. The marketing season is only about 2 ½ months. When picked it stores well. The flavor is fair, rated inferior to Nabal but superior to Reed.

NORDSHTEIN. This is a Mexican seedling in the Zutano-Bacon season. The tree is a strong grower. Production has been good and consistent. The fruit is oval. It averages about 10 oz. The seed is small for this season and the cavity tight. Eating quality is good.

SHOMRAT. Another possible Nabal seedling, it matures later than any other avocado known there, hanging to mid-August or perhaps 3 ½ months later than Nabal. Its fruit is about Reed shape and size (smaller than Nabal). It peels very well. The flavor is rated a little better than Nabal. It alternates, bearing heavily in the "on" year.

ROOTSTOCKS. California has lost about as much avocado acreage to *Phytophthora cinnamomi* root rot as the entire Israeli area planted. It is therefore hardly surprising that this problem has been the major recipient of our research emphasis and funding; and we have made little attempt to identify or develop rootstocks with other special qualities, since root rot resistance is of such over-riding importance to us.

Israel not only has no avocado root rot, it has a more serious salinity problem than we do. And its climate permits the fruiting of the West Indian race that provides an answer to that problem. Rootstocks of the same race provide the best answer also to chlorosis; both California and Israel have high-lime soils, but since the Israelis can plant on more poorly drained soil than we can, their chlorosis problem also may be worse. Moreover, for rootstock performance apart from specific diseases, the Israeli commitment of support funding and highly able scientists is unique.

Hence, excepting only matters pertaining to the *Phytophthora* malady unknown in their country, the Israelis are doing more rootstock research than the rest of the avocado world combined. And they are making discoveries of great value to us all.

There is not space here to discuss their work in detail. I will summarize my impressions of some of their more significant findings.

FIELD PLOTS. With selected seedling rootstocks and known scion sources, experimentally replicated, these now comprise a staggering 70,000 trees in 220 plots on non-governmental properties (largely cooperative farms). The man responsible for this huge project, Dr. Avraham [Abraham] Ben-Ya'acov [Son of Jacob] is ideally suited for the job— he is exceptionally gifted both as a practical researcher and in ability to get along well with everybody. The project is young. Important results are just starting to come in. Some of the findings already emerging are:

1. There are major differences in resistance to salinity and chlorosis (see the next sections).

2. While there are average differences among the three horticultural races in different aspects of rootstock performance, there are often great differences within a race, and complex interactions with scion differences (see Dr. Ben-Ya'acov's article in the 1972-73 Yearbook).Complicating the picture still further are interactions with variation in soil, climate, and culture.

Fruit-set comparisons are the critical factor. Significant differences have already been recorded, but keeping individual yield records with tree numbers of this magnitude is obviously a Herculean task.

3. Most of their rootstock studies have been with the Fuerte, which is fortunate for California's need to save that variety by getting better production. Stock and scion must

be considered jointly. For example, a Fuerte on unknown rootstock was selected as a propagation mother tree because it bore heavily; but all subsequent grafts, on stocks from different sources, were poor producers. On one farm a Fuerte selection gave superior yields on one stock, but on a second stock produced only a fraction of the crop of a different scion source.

On another farm, using a common rootstock source, a Fuerte scion yielded twice as much as a second scion selection, and six times as much as a third (grown in a separate plot). However, relative scion performance might have been quite different with a different source of stocks. On the same farm, a fourth scion source averaged even more fruit than the first, but on another stock so that one cannot validly compare either scions or stocks. All one can say positively is: in this soil, with this weather, and given this culture, this scion-rootstock *combination* is outstanding as compared with the other combinations tried.

Usually, even when chlorosis or tipburn are apparently not a problem, Fuerte is bearing better on West Indian than on Mexican stocks. But performance of the latter especially varies greatly among lines; race generalizations have many exceptions. Among Mexican stocks for Fuerte, Mexicola has performed less favorably; not only are its slim stems harder to graft, but the resulting orchard trees have averaged somewhat less set.

4. Dwarf trees have increasing economic advantage as picking costs rise; scion-varieties like Tova, Irving and Wurtz produce smaller trees, but each has commercial drawbacks, and a dwarfing stock could make *all* scions dwarf. Repeated top-working of Wurtz, so that it is left as a trunk interpiece, has failed to produce discernible dwarfing. Unfortunately, no really dwarfing stock is known in the avocado.

Dr. Ben-Ya'acov's field plots have already shown substantial tree size differences within a variety. For example, the Fuerte selection described as "a fourth scion source" above, was, on its particular rootstock, the smallest tree as well as the heaviest setter. But for neither trait can we tell whether the differences was due to scion or to stock. The only one of his statistically significant Fuerte tree size differences that to my knowledge permits us to identify the source, points to the scion: On the same stock, two Fuerte sources have a trunk circumference difference significant at the 1% level (and smaller trees are again associated with much heavier set). For other varieties, the rootstocks have apparently been identified as the cause of ultimate tree size differences. For example, both Corona and Netaim have produced smaller trees on one West Indian seed source than on another. In none of these cases are the tree size differences great enough to qualify the smaller ones as true "dwarfs."

In all situations there remain cause-and-effect questions. Did reduced tree vigor lead to the heavier set? Or did the heavier set reduce tree vigor? Or are both equally-direct consequences of the basic genetic difference? For immediate commercial purposes, it presumably doesn't matter.

5. While limited observations in California suggested that Guatemalan stocks are more susceptible than Mexicans to *Verticillium* injury, Israeli experience now indicates that the major differences are within rather than between the two races. Most stocks in both races appear to be quite resistant. When stocks known to be resistant are not available, it is best to avoid land that has given avocados trouble in the past, or that has grown

tomatoes or peppers. (See also Dr. Ben-Ya'acov's article in the 1973-74 Yearbook.)

SALINITY. Salt injury is most severe on Mexican stocks (Fig. 3). The best West Indians may tolerate a remarkably high 1000 ppm of chlorine. Guatemalans won't take this much, but there is again great genetic variability among different lines of each race. For example, Fuerte trees have shown considerably more "tipburn" on the West Indian Fuchsia than on the Guatemalan Nabal.

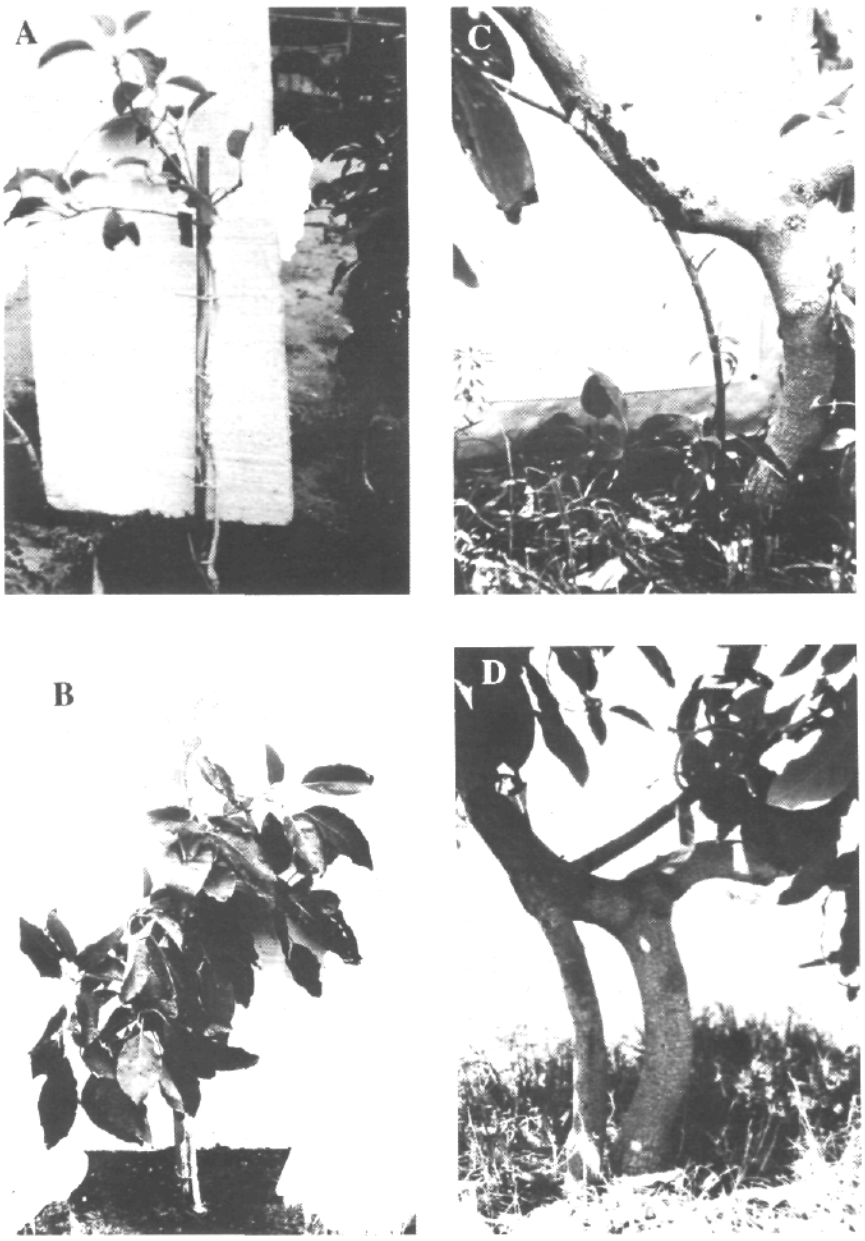

Figure 3. Salt injury and inarching. A, young Fuerte tree grafted on a Mexican-race stock (Mexicola seedling). The tree eventually lost all of its leaves. B, Fuerte tree of the same age grafted on a West Indian seedling. There is no tipburn evident, although the irrigation water here also had 250 ppm chlorine. C shows a tree of Fuerte that has lost most of its leaves due to salt injury. A West Indian seedling has been planted beside it and the two stems joined in hopes of developing an inarch-grafted resistant rootstock. Nurse leaves have been left on the seedling. D, subsequent development: the inarch has grown rapidly, its union with the Fuerte tree is complete, and the tree has produced much more and healthier foliage. (Photographs by courtesy of Dr. A. Ben-Ya'acov.)

As in California, in most regions the salinity problem is increasing. While tipburning obviously reduces photosynthetic surface, considerable leaf breakdown has occasionally be associated with higher yields than those of trees on rootstocks that result in much less tipburn (and no other apparent defect). This points up again the importance of specific stock-scion yield interactions.

Nevertheless, where injury is severe, fruit yields have sometimes doubled by a few years after the successful inarching of mature trees.

Dr. Amnon Kadman has obtained interesting results from some ingenious salinity experiments. The scion top has very little influence on its own susceptibility to salt injury—it's the rootstock that counts. Moreover, radioactive-sodium studies show that resistant stocks do not "resist" salt absorption; rather, they pass on to the top much less of the absorbed salt than do susceptible stocks.

His radioactive-chlorine studies show that by about five days after chlorine-containing water has been applied to susceptible roots, the chlorine is concentrated along the leaf tip and edges just where it will manifest itself weeks or months later as tipburn. It is carried there by the water stream. So salt injury is correlated with the transpiration rate, which in turn is correlated with temperature and relative humidity, which in turn are correlated with the season of the year. It appears to me, therefore, that growers should be especially careful to avoid any soil water stress during summer periods of heat and low humidity.

Dr. Kadman has devised a grove setup for testing salinity resistance under controlled conditions: impenetrable soil barriers forming individual growing plots 6 ½ feet square and 4 feet deep. Artificially saline water of different concentrations is applied to the plots.

Scions used were Hass and Fuerte. Two rootstocks of each race have been tested thoroughly. In all three cases, the members of the pair differed widely. One West Indian rootstock, Fuchsia 20, had excellent tolerance; the second, Lula, is certainly not pure West Indian. While one of the Guatemalans proved quite sensitive, the second did very well—but is harder to propagate. One of the Mexicans was extremely sensitive, as expected; Dr. Kadman thinks the second (GA13) is probably part West Indian.

Hass fruits had 2 or 3% higher oil content on the more resistant West Indian stocks. This is presumably due to better physiological functioning in the absence of salt injury, rather than to direct rootstock effects.

CHLOROSIS. West Indian lines are most resistant, but here it is Guatemalans instead of Mexicans that are most sensitive (Fig. 4). Nabal was widely used in earlier years and is the chief rootstock giving chlorosis problems. Nevertheless, it is still regarded as the best known stock for sandy soils with very little lime.

Dr. Ben-Ya'acov estimated that ordinary Mexican rootstocks are fine for soils with lime content up to about 30 to 40 *%.* They also perform well at higher lime concentrations if iron chelates are supplied. One avocado farmer told me that on West Indian stocks he was growing avocados satisfactorily in soils 80% lime. Magnesium and zinc chelates might be needed at such very high lime levels. Trees were reportedly doing well in 60% lime soil, on West Indian, with no special nutrients added.

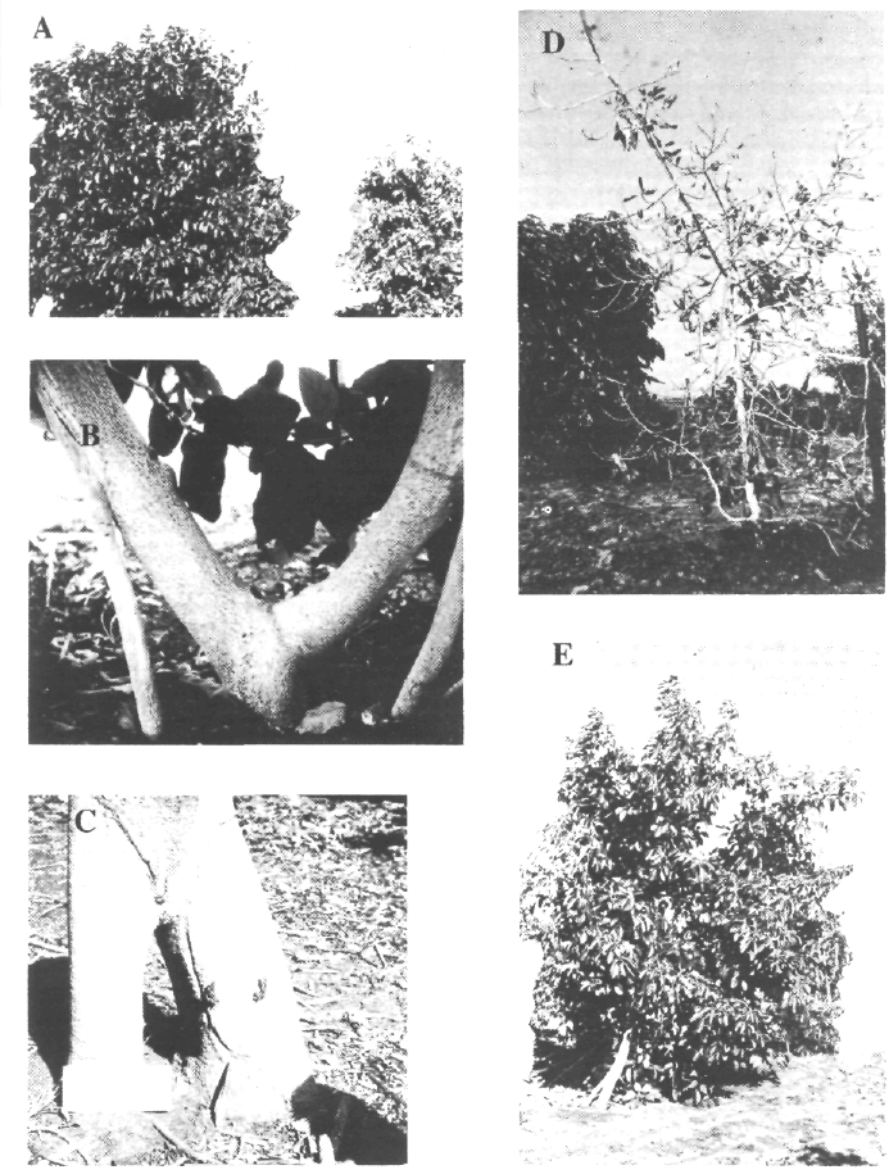

Figure 4. Chlorosis and inarching. A, Fuerte trees, grafted on a West Indian (left) as compared with a Guatemalan stock. The latter is a Nabal seedling. Note that the Fuerte on it is very yellow ("chlorotic") as well as much smaller. B, a forked field tree with each main stem possessing an inarched resistant rootstock. C, an older field tree in which two inarches were attached to the same trunk; the original trunk has largely been swallowed up by one of the inarches. D, the foreground Fuerte is on a Guatemalan seedling and is dying from severe chlorosis, as did most trees on that stock. In the left background is a healthy tree on West Indian. E is in the same plot and shows a Fuerte, originally on Guatemalan, that has been saved by inarching to West Indian. Note how small the inarch is proportionately, and yet the tree is already nearly normal; since chlorosis represents deficiency of a nutrient (iron), whereas tipburn involves toxic excess, response to inarching for chlorosis is much more rapid. (Photographs by courtesy of Dr. A. Ben-Ya'acov.)

Again here, Dr. Ben-Ya'acov has found considerable variation among lines within each race. Between two West Indian sources, one proved more resistant than any other rootstock that he has tested, but the second had actually superior yields with a certain Fuerte scion source, in spite of some visible leaf chlorosis. The importance of stock-

scion "combining ability" is once more demonstrated. He has also observed Fuerte (and Ettinger) trees to be less susceptible than Hass.

Professor Oppenheimer pointed out that chlorosis can be caused not only by high lime but also by anything that injures the roots. Irrigation weaknesses are often responsible, especially an excess, also a deficiency, or wrong intervals. So, in heavier soils, chlorosis can be reduced by planting on ridges, for better aeration. Also by working in organic matter, for the same reason.

Dr. Kadman has cured chlorosis very quickly by pressure injection of Sequestrene 138-Iron (see his article in the 1973-74 Yearbook). However, this must be repeated annually. A usually permanent solution can be obtained by inarching (Fig. 4).

WEST INDIAN ROOTSTOCKS. Their major advantages have been noted above. Especially where salinity or chlorosis are problems, but even under good growing conditions, at least Fuerte often bears more on West Indians. With the nearly universal commercial method of propagating rootstocks, by seed, they have the additional advantage of being more genetically uniform.

As nursery seedlings, West Indian groups are noticeably more alike than groups of the other two races. And there is evidence that this carries through to grafted tree performance: Fuerte yields have apparently been more uniform (and usually good) on West Indian, as compared with an often more variable set (ranging down to poor) on the standard Mexican stocks, using seeds from a single tree of each race,

Trees used for rootstocks are seldom sufficiently isolated to prevent cross-pollination. Hence, rootstock performance can be expected to vary with pollen source. Israeli West Indian stocks are said to fall into two major groups: those resistant to both salinity and chlorosis, and those resistant to salinity only. Moreover, the latter are often more vigorous, possibly suggesting a racial hybrid origin.

This makes sense. I was given, as a rough approximation, Mexican bloom ending about the beginning of April, Guatemalan through April, and West Indian the first half of May—at least, probably too late for Mexican flowering. Guatemalans are more resistant to salt but less resistant to chlorosis than Mexicans. Thus, outcrossed West Indians rootstocks are expected to be more chlorosis-susceptible.

Wilson Popenoe has been quoted as believing Lula to be a West Indian-Guatemalan hybrid. This would explain the susceptibility of its seedlings to chlorosis. Its cold-hardiness may suggest some Mexican ancestry also, which could explain why as a rootstock its salt tolerance is below that of pure West Indians. And Lula seedlings are exceptionally variable, which fits with a hybrid origin.

Pure West Indian lines do have certain drawbacks. They are much more difficult to propagate asexually, if that becomes desirable. They are too tropical in adaptation to fruit much in California; we have imported such seed from Florida. Their cold tenderness makes them more risky when rootstocks are grown out of doors over winter. Following heavy winter rains with consequent standing water, Israeli trees on West Indian have seemed to suffer more. Because of the root rot danger. Californians do not—or at least should not!—plant on such poorly drained soils, but Dr. Kadman thinks

that the sub-performance of West Indians under these conditions is more likely caused by their greater susceptibility to chilling rather than to poor aeration, which would again point up our climatic limitations.

California observations years ago led to some feeling that West Indians are just too cold sensitive to make satisfactory rootstocks for us. This was based largely on outdoor nursery experience with the Waldin variety, which is unusually cold hardy for a West Indian as well as having a large seed ratio. But Waldin seedlings are also rather weaker growers; other West Indians might well perform better over our winter season. I have seen no good evidence that trees grafted on West Indian are themselves more cold tender. After one singularly severe freeze in Israel, Hass trees on West Indians side by side with Mexicans showed no difference in average injury.

Considerable numbers of West Indian rootstocks have been grafted in California recently. Should we be switching primarily to that race? This would lead to serious seed supply problems. A solution might be something like the following. A block of isolated trees is grown (preferably top worked for quick fruiting) in a more tropical region such as Florida or Hawaii, with a cooperative program so that the flesh is made into commercial guacamole and the seeds are shipped to California.

What West Indian should we use? One thinks first of choice root-stock lines identified in Dr. Ben-Ya'acov's field plots. Another possibility is lines that were not available for testing when his plots were being set up, which could be superior.

Dr. Kadman showed me seedlings of the Maoz, which are exceptionally uniform even for a West Indian line and so greatly reduce the need for asexual propagation. Moreover, they are exceptionally salt resistant even for West Indians, and highly resistant to chlorosis as well. They are very cold tender. Set on the parent tree has been heavy. The fruit weighs about two pounds with flesh of good quality; it would be difficult to use its seeds economically unless the flesh could be sold commercially.

But perhaps there are already available in Florida or Hawaii sources of West Indians that better fit our needs. These could have relatively large seeds and small fruits, thus simultaneously maximizing the number of seeds per tree and minimizing the amount of flesh per fruit.

Professor G. A. Zentmyer is moving ever nearer a commercial answer to root rot. The most likely solution appears to be sufficiently-resistant, compatible stocks. Such stocks would, for us, make all present stocks obsolete. But this development may be still several years away.

In the meantime, consider the following. Our present standard California stocks, such as Topa Topa, have nothing special to recommend them except local availability and a good stand of vigorous seedlings. Most California groves suffer more or less from tipburn—with a probably corresponding loss of production. Chlorosis is a problem here and there. The West Indians that solve these diseases are even in their absence (at least in Israel) apparently conducive to higher yields (at least of Fuerte). It seems clear that better rootstocks are already available than those we are now generally using.

Are there perchance still better stocks available to us? Compatible avocado relatives, of which at least the *nubigena*- and *floccosa*-forms fruit satisfactorily in California, have not

really been adequately tested.

ASEXUAL PROPAGATION. It is of importance to us now in connection with Dr. Zentmyer's identification of lines with some resistance to *Phytophthora.* It will become of much greater importance when he develops a line with the greater resistance needed to solve the root rot problem, assuming, as seems likely, that the line will be genetically variable for this resistance. It may become of great importance considerably sooner if we identify one or more rootstocks that effect heavier yields of Fuerte or other varieties. Such stocks could be part of a stock-and-scion "double copy" tree outstanding in California or elsewhere, or a more general stock directed toward the same end but produced perhaps by hybridizing a selected West Indian (possessing the advantages noted above) with a selected non-West Indian (to add hardiness).

Dr. Oded Reuveni is doing most of the Volcani work on vegetative avocado propagation. He believed that asexually propagated stocks can do much to advance avocado culture. And that plant breeders developing superior stocks should stress clonal propagation ability—a point made also by Professor Pinhaus Spiegel, Head of the Fruit Tree Breeding Division (and of the entire Fruit Tree Institute). Prof. Spiegel thought that rootstock breeding with West Indian lines as one parent, could be quite beneficial.

Our Ted Frolich's etiolation method works fine with Mexicans like Duke #7, but not with pure West Indians. While members of the latter race have proven much more difficult to root, they vary markedly among themselves. Both the propotion and the speed of rooting have been greatly increased by methods that increase juvenility. These include repeated grafting and repeated cutting back of the new shoots. Dr. Reuveni found a temperature of 30°C [86°F] at the cutting tip to be optimum. Much better than vermiculite as a rooting medium, are mixtures of organic and inorganic materials, such as peat moss plus volcanic tuff. Best rooting is obtained mid-June to mid-summer.

An important rooting factor is leaf retention by the cutting. So Mexican lines hold their leaves better than West Indians, and, among Mexican lines, those that will root better first hold their leaves better. Retention seems to be limited by both abscission and senescence. Dr. Reuveni has found that a combination of chemicals that delay these two processes, one acting as a cytokinin and the other as an auxin, significantly increased both leaf retention and rooting. He suggested a hunt for West Indians (or their racial hybrids) with fruits that hang exceptionally long after maturity, a trait that hopefully is correlated with leaf retention and so with rooting ability.

If seedling rootstocks are a major source of variable performance of the grafted tops, the question arises as to why our own-rooted Bacon grove at the South Coast Field Station has shown so much intra-variability. Dr. Ben Ya'acov suggested that these trees seemed to be quite variable at the time of planting, and that this has carried through. He thinks that Ted Frolich's etiolation system is producing highly uniform material.

Dr. Reuveni suggested that work should have been done sooner on "double copying"—reproducing both scion and stock, of trees with really outstanding production. Israel now has such trees, but they are not yet bearing. This method has been suggested by Dr. J,

Eliot Coit and others as perhaps the best way of increasing Fuerte production to satisfactory levels in California.

Anyone interested in more detailed—and trustworthy!—information on asexual avocado propagation in Israel should contact Dr. Reuveni (and Dr. Kadman).

COLD STORAGE. Here the researchers are Dr. G. Zauberman and Dr. Mina Schiffmann-Nadel. I understand that the usual storage temperature for California avocados is 6-7°C. In Israel they prefer 5-6°. Perhaps 4°C is still better. However, this would need a setup with little temperature variation: the lower the thermostat is set, the greater the risk of a fluctuation low enough to prevent eventual proper softening.

Varieties differ greatly in their response to cold storage. Anaheim stores very poorly. Bacon stores longer; Fuerte, Ettinger and Irving longer yet. Nabal is still better, and Hass perhaps the best of all the varieties that they've tested. (Which is cause for rejoicing by Californians!) Any new introductions should have cold storage tests as a prerequisite.

This appears to carry through into field performance. For, with prolonged temperatures near 0°C, fruits of Nabal have suffered less quality damage than those of Fuerte, even though the tree of the latter is considerably more cold hardy.

Again, any reader with special interests in this field is referred to the authorities named above.

GIRDLING. This is a much more controversial matter among Israeli avocadoans than I had gathered from the literature. It was strongly favored by Farm Advisor Gefen and by many growers. Yet Dr. Ben-Ya'acov and other growers felt that it frequently is not only a waste of labor but may actually do more harm than good.

Professor Oppenheimer divided Fuerte trees into three groups on the basis of yield: heavy, intermediate, and poor, and suggested that only the middle group is consistently helped by girdling.

On heavy yielders, girdling may hurt both the tree and the fruit it is carrying. I saw a few Fuerte groves in which that seemed to have happened to most trees. Foliage was still sparse, stunted and sometimes chlorotic, a year after the girdling. Fruits were numerous but undersized and often deformed. Moreover, while the set appeared at first glance to be extremely heavy, Dr. Ben-Ya'acov pointed out that partly this was a misleading consequence of the foliage being so scanty that nearly every fruit is obvious! Fuerte yields up to 27,000 Ibs/acre have been reported following girdling of about ¾ of each tree, which appears to be too much for the trees to handle without injury. Some trees looked as though they might need years to recover.

Conversely, the really poor producers do not seem to be helped much by girdling. Whether they are deficient because of climate, other environmental factors, cultural weakness, disease, or inferiority of stock or scion, girdling seems rarely to remedy the problem.

That leaves the intermediate-yielding group. While we have quite a few representatives in the two extreme classes, probably most California Fuertes fall into this median range most propitious for girdling. Several Israeli growers told me that they had about doubled their Fuerte crops by girdling. But in the absence of a replicated experiment with checks and published actual figures, one is less certain. Also, it is often too early to know the long-range results. And there are a few oral reports of little or no benefits.

The problem is that even in Israel the procedure has been practiced on a large scale too short a time to provide definitive answers. There is still much uncertainty concerning girdle width, timing, frequency (annual or biennial), proportion of tree. And a minimum of several years' results is necessary for positive conclusions.

In one grove, the entire trunk was girdled below the lowest branch and the girdle was about ¾ inch wide. This certainly seems a dangerously drastic treatment; but carried out every other year, it was said to be giving fine results under these particular circumstances. I saw no dead trees, and none that seemed seriously weakened. At the other extreme, one grower claimed good results from a girdle only the width of a pruning saw.

I was told that October is the best month to girdle Fuerte. And I was told that it should be girdled in spring when the main bloom is starting.

I have assumed that girdling is desirable only on vigorous trees, to tip the balance toward fruitfulness from excess vegetative growth. But growers there reported excellent response from the dwarf Wurtz variety. In one grove I saw little Wurtz trees shaped like an umbrella or toadstool, with fruits hanging abundantly inside like on an arbored grape vine, and little fruit on the (few) checks; half of each tree was girdled each year. In another grove, half-tree girdling did not seem enough for Wurtz, no ¾ of each tree was girdled each year. The trees have reportedly averaged 16,000 Ibs/acre for the three years since this heavier treatment began. But this past summer they made practically no growth, so the future is dubious.

Girdling is said to be especially beneficial for varieties like Wurtz that bear well when young and then taper off. Ettinger and others reportedly behave similarly in some locations.

The Ettinger erect tree shape has benefited from girdling the main stem above side branches that are thereby encouraged to develop, producing a more spreading tree. This should be tried on Bacons, Zutanos and Reeds. Will longer side branches be more subject to breakage?

Benik is an example of a variety that ordinarily bears poor crops, but which generally sets well when girdled. Also unlike Fuerte, its trees are almost never hurt by the girdling. Regular production has been maintained in crowding Ettinger and Nabal trees by combining girdling with heavy pruning in the off year.

Where Fuerte and Hass trees are interplanted and the former are girdled, their tree size becomes noticeably smaller. Hass is rarely girdled in Israel, since its fruit already tends to be small for their markets and more fruit means smaller average size. (One Ventura County grower whom I have visited is regularly girdling his Hass trees; the fruit is not harvested until about October, permitting it to size up).

What conclusions from the Israeli experience might we draw for California?

1. It should be tried, especially where set in less than satisfactory—on Fuerte, also Bacon and others.

2. It is safest to use a narrow girdle (say 3/8 inch or less) on only about half of each tree each year.

3. Replicate treatments so that differences due to grove location can balance out.

4. Keep enough ungirdled "check" trees to give a meaningful comparison.

5. Maintain careful yield records—the eye can be deceiving!

BREEDING. This was the primary purpose of my visit. The Israelis are beginning a major avocado breeding program. This may seem surprising considering that breeding is by its nature a long-range program; that the present severe austerity in Israel has required sharp cutbacks in the research budget; and that in California, with an industry several times as large, the powers-that-be have seen fit to gradually curtail the avocado breeding work.

The able Director of the Volcani Center, Professor Joash Vaadia, acknowledged that tree crop breeding payoff in terms of proven superior varieties can only be expected after decades, but he still supported the avocado program as a sound investment. He did so partly from his judgment that while broadly physiological approaches have made many important contributions to avocado culture, they have reached the point of diminishing returns. Genetics and breeding now have probably more to offer.

And the Head of the Department of Subtropical Horticulture, Dr. Shmuel Gazit, emphatically supported the new program: no present variety is fully satisfactory; in avocados we have as yet hardly more than scratched the surface of genetic possibilities; while it is true that the budget situation is extremely tight, breeding now merits exceptional support; one part of the world cannot very effectively breed for another part, i.e. California for Palestine—or vice verse!

Listening to the discussions, I couldn't help but wonder if time will not prove their insights on this matter distinctly superior to ours . . .

They are concerned about an impending new law that would lead to the patenting of their new varieties. In the meantime, they are freely sharing with us any of their new selections. These can be expected to increase in number and value as their breeding program develops. Both our industry and theirs will profit most from an unhindered mutual exchange, without charge, of all new selections, locally patented or otherwise. Hopefully, we will act accordingly and so enable them to continue to do likewise.

We exchanged much breeding information and many suggestions. To discuss them here might well double the length of this article. Moreover, most of them are of a technical nature and not directly applicable by growers to problems in their own groves. The two breeding programs will be applying them toward the development of new, improved varieties, for the betterment of the avocado industries in both countries.

CROSS-POLLINATION. The California breeding program has produced a number of side-benefits apart from new varieties, including cross-pollination data. Already the Israeli program has added to this data. Their breeding program is headed by Mr. Shimon Zackai, M.Sc., a dynamic young man brimming with resourceful ideas. From caged trees of several varieties given several treatments he has some important findings.

He has confirmed for Palestine the California discovery that the honey bee or other large flying insect is necessary for worthwhile fruit set: when bees are not placed within the hive, even adding cross-pollinator branches results in no (or almost no) fruits. He has also confirmed that with bees present, cross-pollinators result in much more fruit than when set depends on self-pollination within a given variety: over two seasons (three seasons for Fuerte including its crop just harvested), three different varieties yielded from two to four times as much when each had a cross-pollinator in the cage.

This basic similarity to our results gives confidence that his additional data are also applicable to us. In California, whenever I have studied grove setups that permitted comparison of check trees with others exposed to cross-pollination, the latter have set more fruit. Limited and tentative observations have indicated this to be true of Hass also. Now Mr. Zackai has confirming experimental statistics. Within his cages, Hass set is increased by cross-pollination just as strikingly as is average Fuerte set. Moreover, the pollinator used was Fuerte—it blooms earlier than Hass and most likely would be less effective than other available pollinators. Cross-pollination should certainly be tried where Hass set is substandard.

Mr. Zackai has compared different pollinators for caged Fuertes. Tova gave greater average increases than even Topa Topa. The increase due to Hass runs much less (although it still resulted in average set some 50% higher than self-pollinated Fuertes). This agrees with their observations that, as compared with pollen of Tova or of Fuerte itself, Hass pollen germinates poorly on Fuerte pistils and then may penetrate the style only part way.

Different Tova pollinators were also compared. Ettinger gave outstanding results, Horshim and Naval much less although still considerably more than the selfed trees. This comparison also gave interesting apparent differences in seed shape due to pollinator differences. With Ettinger as male parent the Tova seeds averaged most elongate, with Nabal they were most round, and with Horshim they were intermediate—conforming with the seed shape differences among these three pollinators. No corresponding Tova fruit shape differences were noted.

Mr. Zackai also compared amount of cross-pollinator available. For both Hass and Tova, while a single grafted Fuerte branch about doubled the self-pollinated set, an excess of available pollinator about doubled it again.

Finally, he has thrown some light on our old question of the origin of "cuke" fruits. Are they small and slim because they began development without fertilization and so without an embryo, or is an embryo necessary to prevent abscission and cukes result when the embryo dies subsequently? The latter interpretation is favored by intermediate "cuke" sizes that appear to represent intermediate times of embryo death. Mr. Zackai has results also favoring the second hypothesis: caged Fuertes bore several times as

many cukes when enclosed with a cross pollinator that would provide extra fertilization. However, the trees without any bees averaged more cukes than trees self-pollinated. Possibly both processes can produce cukes. More data are needed.

In the field, Benny Gefen has observed benefits to Fuerte set from both Hass and Ettinger. Reasonably enough, the largely Guatemalan Hass appeared to be more beneficial when planted on the side of Fuerte that increased its sun exposure and so advanced its period of bloom relative to Fuerte. Conversely, the largely Mexican Ettinger appeared to be more beneficial with just the reverse exposure.

Reed is now replacing Benik as a pollinator for Nabal.

From his observations, one Farm Advisor believes that adding hives of bees to an avocado grove is an effective way of increasing fruit set, by better pollination. Four hives per acre appear to be below the optimum concentration in some years, especially when the weather is unfavorable.

Mr. Gefen has studied the ordinary housefly at work on avocado flowers and concluded that it seems to be an efficient transporter of avocado pollen. It would be interesting to investigate this. Although one hesitates to deliberately increase our fly population, a location that already has a heavy fly concentration just could be a highly favorable spot for an avocado grove. But I personally would not rush into it. Field #5 at the South Coast Field Station adjoins an egg ranch. The chickens produce manure, the manure breeds flies, the flies attract spiders, the spiders build webs, and the webs keep catching you across the face as you examine the avocado trees. This is especially disconcerting when your mouth is open, as sometimes happens when you walk along peering upward at fruit or talking to your assistant. And sometimes my assistants have been moved to say unkind words about webs, spiders, flies, chickens, me, and avocado breeding in general. Now that I've had to start abandoning groves, the first field to go was—#5!

MISCELLANEOUS. This will include a number of points that may be of importance to California growers or researchers.

FERTILIZATION. Israeli experimenters have given results contrary to the nice bell-curve relationship between leaf nitrogen content and fruit yield reported from California. They do not feel that a precise value for optimum nitrogen is reasonable, since the optimum can be expected to vary with temperature, etc. Could our results have been a "neat coincidence?"

Dr. Kadman has results indicating that zinc foliar sprays, under his conditions, would be of very little benefit. Unlike with some crops, the zinc material failed to move significantly away from the avocado leaf stomates that it entered.

IRRIGATION. In one young grove, sprinklers had produced better trees than spitters. In another grove, after fruit had set, irrigation intervals of from one to four weeks made very little difference in fruit development or apparent tree condition. However, Professor Vaadia. who has worked on avocado irrigation in California, thought that some of our

groves might be suffering from too infrequent irrigation. A new irrigation system has soil moisture maintained at a precise level by water supplied as often as several times an hour; it looked very good for grapefruit and is being tried on avocados.

DRIP IRRIGATION. Bananas and mangos were commonly being grown under this system, and I was told that the same is true of the dates grown in the southern deserts. All three of these crops require a warmer soil—which Drip produces. I don't recall seeing an older avocado grove on Drip, which is not unreasonable since the root system under the two systems tends to be quite different.

But very few of the newly planted avocados were on Drip. And this is the country where Drip originated. When I expressed surprise, I was told that they consider the extensive use of Drip for avocados (or citrus) premature. They think that experience with it is too limited to justify its extensive use as yet. Drip does seem to have certain advantages under certain conditions. But problems are also emerging. They question the desirability of the large-scale switch to it that California is experiencing. Such apparent advantages as have been observed for Drip may be due at least partly to one or more of the following: special local circumstances, incorrect management of the older systems (especially too infrequent irrigation), or advantages with young trees that will prove transitory and misleading. For them, the wise word at this stage is "caution."

SUNBLOTCH. Strange things happen concerning it. Dr. Ben-Ya'acov has repeatedly watched inexplicably poor-bearing trees, otherwise perfectly normal, which when topworked come down with sunblotch. So they were presumably "hidden carriers"—but why then were they nearly fruitless?

The Reed is more confusing. When Fuerte, Nabal, Ettinger and other varieties were topworked on these unfruitful trees, they all developed severe sunblotch. But the Reed topworks look completely healthy and are setting heavily. (I saw such trees of it and of the other, obviously diseased varieties.) So is the Reed a hidden carrier? In fact one of the first descriptions of the Reed set forth results just like the above in California, using grafts from the original tree. On that basis it claimed that Reed is "resistant" to sunblotch. I therefore became suspicious of a hidden carrier situation and urged Bob Drake of U.C. Riverside to test it. The test was negative: "no sunblotch." Moreover, some Reed trees have reportedly come down with distinct sunblotch.

What is the explanation? Is the Reed after all in some way exceptionally resistant to sunblotch symptoms? Or are there different strains of the virus, and is Reed a hidden carrier of one strain? Or is there some simpler explanation?

It might be clarifying to work Reed onto some of the diseased top-works of other varieties noted above. And indexed wood of other varieties should be worked into the healthy Reeds on the previously unfruitful trees. Has anyone in California experiences or interpretations that may throw light on all this?

The extent of symptoms does vary among lines. They noted that sometimes sunblotch actually results in heavier set on smaller trees, with almost no fruit deformation—at least in Israel. Mr. Zackai was encouraged to propagate a sunblotched seedling, which was

carrying a huge crop when we saw it.

OPTIMUM TEMPERATURES. For seedlings or young grafts, Dr. Kadman has found that maximum growth occurs when the top is considerably cooler than the roots. Precise optima have not yet been established. Perhaps they vary with other factors. Dr. Kadman established that when the entire tree is kept at about 25°C (77°F), growth is considerably slower than when the roots are at 25°C but the top is at only 15°C (59°F). My own experience suggests that greatest growth in my young seedlings has been obtained when both values are considerably higher, but I have no precise data.

BLOOM TIME. From earliest to latest, the relative flowering period is approximately as follows: Mexicans; Fuerte; Ettinger; Hass; Reed and Nabal; West Indians. The Mexican-to-Guatemalan progression is consistent except for Ettinger, which, although it is shown by its harvest period and other traits to be mostly Mexican, blooms later than Fuerte which is about half Guatemalan. A possible explanation for Ettinger's later bloom is the speculation that it has a few West Indian genes. Such could also explain its glossy skin.

Our Zutano also blooms later than its mostly Mexican genes would lead one to predict. Late bloom could well help explain its superior setting ability: it flowers when the weather is warmer.

FLAVOR PROBLEMS. Ettinger is their earliest-maturing major variety, and as such its picking has tended to start too soon. Oil percentage is above the arbitrary 8% level and fruit size is adequate when the flesh still tastes flat. Dr. Gazit therefore encouraged a two-week delay in the beginning of picking, and an oil minimum of 9%; he now thinks that an even somewhat higher oil percentage minimum may be desirable.

Ettinger fruit flavor improves as long as the fruit remains on the tree, substantially past the time that it is too mature to ship well. This also parallels our Zutano and probably Bacon, which usually taste better the longer they hang, but which are not commercial late in their seasons because of skin deterioration. Fuerte and Hass are different in that their palatability declines toward the end of their respective seasons.

Dr. Gazit sometimes experiences a bitter aftertaste, roughly 20 minutes subsequent to eating fruit with this unknown component. He finds it in most varieties when they are immature. But it is never noticeable in Nabal, whereas Anaheim fruits may have it right up to maturity. Once this aftertaste develops any avocado sampled seems to have the bitterness, until it wears off a half hour or so later. I do not recall ever experiencing this. Possibly the off-flavor affects me differently in terms of both timing and nature. Flavors are notoriously individual matters. The difficulty for rating present varieties and selecting new ones is obvious.

YIELD LIMITATIONS. While avocados do bear comparatively well in Israel, other fruits yield much more. For example, grapefruit trees produce 100,000 Ibs/acre and up; if average yields are less than 80,000, it is recommended that the trees be removed. But

Professor Oppenheimer pointed out that avocados have a much higher percentage of dry matter than does citrus, and so comparable yields would be unreasonable.

GEFEN'S MISCELLANY. To some extent the counterpart of our Don Gustafson, Farm Advisor Benny Gefen had some additional stimulating observations, which I will throw in together. He considered the loss of some overloaded limbs an evil lesser than that of bracing all such limbs, with its cost in time, materials, and the inconvenience of grove props. (Might not at least Nabal be a valid exception?) During their recent worst-ever freeze, he noticed that not only the slopes, but also the middle areas of broad valleys, were warmer. In their Hass trees, the south-east sector had the best set and the largest fruits.

Mr. Gefen suggested an advantage of the Israeli industry over ours: most of their acreage is managed by people with so little avocado experience that they are more open to new ideas. Nevertheless, he judged a California grower whom he has visited as doing a superb job, unsurpassed by any known grower in either country. (I will not embarrass the grower by publicly naming him—but I plan to visit him as soon as possible myself!)

RESEARCH MISCELLANY. Their avocado research falls into three time scopes: Long range, e.g. breeding; medium range, e.g. scion-rootstock trials; and short range, e.g. ovary studies.

Dr. Kadman said that the West Indian race has a uniquely high content of a certain 7-carbon sugar. And he stated that electron scanning microscopy has revealed major-differences between the leaf cuticles of Fuerte and Hass. Might these differences provide new tools for differentiating races and race proportions?

Dr. Ben-Ya'acov had found surprisingly poor correlation between trunk circumference and tree spread. Possibly differences in tree height balance it out; I saw alternate trees on Mexican and West Indian stocks that had about the same average circumference by measurement, but those on Mexican averaged clearly taller. Any real rootstock race differences in ultimate grafted tree shape would be most interesting. In any case, tree spread is the significant factor for planting distance and eventual thinning. Dr. Ben-Ya'acov has devised a sector method of tree spread measurement, which correlated closely with actual measurements from aerial photographs.

It was fitting that on the day we left Israel, a news item on avocados appeared in the English-language *Jerusalem Post.* The article noted that this year their Fruit Production and Marketing Board is making more of a pitch to the lower-income [younger?] brackets— even as our California Avocado Advisory Board is doing. The article pointed out that avocados, considering their food value, are "quite a bargain." The Board has issued a collection of spicy avocado recipes for connoisseurs of oriental food. Israeli avocado exports are reportedly up 25% this year.