

The Avocado Industry in Palestine

Chanan Oppenheimer

From Bulletin 44, Agricultural Research Station, Rehovot, Palestine, October 1947. Abstracted and condensed by the editor.

Palestine is a subtropical country with a rainy winter season. Climatically it is divided into three regions: the coastal plain, the hill country and the interior Jordan Valley. The coastal plain and Jordan Valley run parallel from north to south and are for the most part unconnected. The Jordan Valley lies below sea level.

Temperatures in the winter or rainy season, which begins in November and ends the middle of March, are generally low, but may reach 86 degrees F. on cloudless days. On the coastal plain, on rare occasions, freezing temperatures may occur near the ground. In low pockets, lacking air drainage, temperatures as low as 23 degrees F. have been recorded.

Spring begins about the middle of March and is characterized by alternating cool and very hot dry days, the latter known locally as "khamsin days" when the wind blows from the east and southeast from desert areas. Under such conditions the temperature may range from 104 to 122 degrees F., which is often the year's absolute maximum. Marked variations in the number and intensity of the hot dry khamsin days are observed from year to year. The damage caused to flowers and foliage by this combination of heat and dryness can be very great.

The summer, from the middle of June to the middle of September, is characterized by hot rainless days, but maximal temperatures seldom equal those reached on khamsin days in the spring. The average number of hours of sunshine per day is high.

The total amount of precipitation varies in different parts of Palestine. On the plains the trend is from high to low, proceeding from west to east and from north to south. From a horticultural viewpoint, differences in the total amount of precipitation are less important, as subtropical fruit trees cannot be grown successfully anywhere in Palestine without irrigation. In April irrigation starts and continues from six to eight months. The avocado, which flowers in the spring, should be well watered whenever a khamsin occurs.

Average annual precipitation is about 24.5 inches at Jerusalem, 19.0 inches at Rehovot, and 6.0 inches at Jericho, which is in the Jordan Valley a short distance west of the northern end of the Dead Sea. In months of less than two inches of rain, there will be a soil moisture deficit and irrigation will be necessary. Relative humidity is much lower in interior valleys than near the coast. On khamsin days relative humidity is very low, sometimes dropping to 6%, the lowest ever recorded at Rehovot Station. Such extreme

dryness may cause necrotic spots on young fruits of avocados, as well as serious harm to young fruits and flowers.

In Palestine normal daily winds blow from two directions, during the day from the west, and at night from the east. Day winds may be strong enough to cause some breakage of trees and windbreaks are advised around the borders of exposed situations. Damage from khamsins is due more to heat and dryness than to the force of the wind.

Avocado trees were first introduced into Palestine in 1908, but trees of known varieties, the Fuerte and the Dickinson, were not introduced before 1924, and real progress in avocado growing in Palestine was made only within the last two decades. During that period seeds and budded trees of a fairly large number of well-known varieties were introduced into this country, mainly from California, by official bodies and private enterprise, such as the Division of Horticulture of the Department of Agriculture, Government of Palestine; the Agricultural School at Mikveh Israel; and two private growers, one in the southern and one in the central part of the coastal plain; a number of varieties were introduced by the Agricultural Research Station at Rehovoth.

Avocado culture in this country has spread into the interior valleys since 1937, when the importance of the West Indian race as a rootstock highly resistant to alkaline irrigation water was realized.

In recent years a few commercial groves were planted in this country, while a fairly large number of avocado trees, mainly seedlings, were planted in home gardens all over the coastal plain. But as fruit produced by most seedling trees was of inferior quality, the planting of budded trees for general purposes has been encouraged. Seedlings should be planted by public agencies and such growers who are keen to raise new varieties.

Small but steadily growing quantities of avocado fruits are selling in the principal towns of the country at comparatively high prices, especially during the years of the war. Until now, due to these high prices, the avocado fruit has not become part of the daily diet of the Palestinian masses; on the other hand, the quantities of fruit available were too small to satisfy a greater demand. It is hoped that, through better understanding of the peculiarities of avocado growing, greater quantities of fruit will become available, thus forcing down the price and making it possible for larger sections of the population to use it as a foodstuff and benefit by its nutritive value.

Optimum climatic requisites for the three avocado races differ greatly according to their respective countries of origin. However, certain climatic requirements are common to all three of them. Generally, all avocados prefer a maritime climate, in which strong contrasts between the seasons do not occur. The most exacting in this respect are the West Indian types which are, therefore, grown only in tropical or near-tropical conditions; Guatemalan types are intermediate, but even the hardiest types of the Mexican highland race suffer more from extremely hot summers or extremely cold winters than the persimmon or even the mango. Mild winters, cool summers and fair to high humidity represent the ideal combination of climatic conditions for the growing of the avocado.

With regard to winter hardiness, Mexican varieties are comparable to the orange and are not seriously damaged by temperatures as low as 25 degrees F. Guatemalan

varieties compare with the lemon, and West Indian varieties are, if anything, more tender than the lime, showing considerable damage already at 28.4 degrees F. Nevertheless frost damage is seldom very serious in the warmer subtropical countries and it may even be prevented, to a certain extent, by orchard heating. Much more serious and difficult to overcome is the damage caused by excessive heat and dryness. The fruit of the avocado varieties ripens properly with heat units, which would be by far too low for the ripening of mango fruits. However, avocado trees may be sun-scorched and its fruit may drop even after a short spell of hot and dry weather. On the other hand, while cool and moist weather at flowering time may seriously impair the set of mango fruits, it apparently does no harm, and may even be favorable, to the set of the avocado fruit. In regions of moist summers fruit-skin diseases can seriously harm both avocado and mango fruits.

Reliable information from abroad regarding the soil requisites of the avocado has not been forthcoming. One soil requisite, good drainage, seems to be absolutely essential for avocado growing and was noticed everywhere. Provided good drainage, avocados were planted successfully on a very wide range of soils, from sand to heavy clay. The writer has himself seen well grown avocado trees on a very poor acid soil in South Africa, while in Palestine trees are grown on soil of over 40% lime content.

In common with other countries, the climate most suitable for avocado growing in Palestine is a maritime climate, which is found here, such as it is, in the northern half of the coastal plain. In general, winter and spring temperatures in the coastal plain are favorable for avocado growing, and in most years varieties of the Mexican race flower within that time. As far as is known, Mexican types have not been damaged by frost in this country, while Guatemalan types in low-lying places occasionally suffered slight damage. The Collinson, a Guatemalan-West Indian hybrid, and the few West Indian seedlings planted in the coastal plain, were severely damaged several times during the last decade, the latter at least on one occasion were nearly killed by frost. The critical climatic period for the Mexican and Guatemalan varieties is after flower set of the former and during the flowering of the latter, namely from April to late May or early June. The climatic conditions in this period, that is, the number and severity of khamsin days, decide the fate of the avocado crop. Long periods of khamsins, or short but very strong ones, considerably reduce or even destroy yields. On the other hand, seasons with few, slight or very late khamsins are favorable for the production of a good crop. Damage caused by khamsins to leaves or young shoots can quickly be overcome but the damaged young fruit is usually lost. In mature groves where the trees form their own microclimate, the effect of this factor, the khamsin, on the crop seems to be somewhat decreased. Normal summer temperatures in the coastal plain do not seem to be too high for avocado culture, as is evident from the very satisfactory tree growth and normal development of the fruit which has been carried through the critical period.

Trials to grow avocados in the interior valleys have been going on for about ten years only. Both Mexican and West Indian seedlings and some budded trees have grown well in this region and have suffered no damage from low temperatures in winter or from high temperatures in summer. West Indian types may safely be used there as stocks, although temperatures sometimes drop close to a point dangerous for them. No conclusion can yet be reached on the influence of the strong khamsin days of the

interior valley on the fruitfulness of avocado trees of different varieties.

In the coastal belt, soils most suitable for avocado trees seem to be somewhat heavier than those preferred for the mango. This, however, might only be a question of water duty, as with very frequent irrigation avocados can successfully be grown on light soils. Well drained and friable grey soils with a medium clay content have so far proved to be best suited to avocado culture in this country. Avocados can also be grown successfully on brownish red soils if they are well drained. Heavy soils are usually imperfectly drained and are therefore quite unsuitable. It seems that a well drained soil cannot be too heavy. Young avocado trees in the interior valleys have made good growth on soil of type D, with good drainage and irrigation water low in alkaline. Pine trees of Mexican stock have been grown in one place on soil of type E with 30-40% of lime and with irrigation water containing about 70 ppm. chlorine. On the other hand, in other places with almost identical soil but with irrigation water containing 200 ppm. chlorine, West Indian types have proved to be far superior to Mexican, as trees and as rootstocks. Most Mexican trees have, sooner or later, degenerated with all signs of severe chlorosis, but all the West Indian trees have remained healthy, as have almost all the Mexican and Guatemalan varieties budded onto West Indian stocks.

VARIETIES

Most avocado trees grown in Palestine are seedlings, mainly Mexican, but there are also some Guatemalan and a few West Indian seedlings. No seedling fruit of such a quality that it would warrant a special description has yet been found; however, some good types, especially fall ripening, are under observation and it is hoped that one of them will be found suitable to fill the gap in the ripening season between the Mexicans and the Fuerte.

Mexican seedlings usually grow well and start yielding from the fourth year. They tend to be quite prolific but in most cases their fruit is of low market value, small with a black skin and a large seed. Guatemalan seedlings have grown to splendid trees, both in the acclimatization garden and in some private groves. The mean height of the trees in the acclimatization garden is nearly 30 feet and their mean trunk girth somewhat over 40 inches. One or the other of these wonderful trees bore an enormous yield in single years. However, most of them have given only comparatively poor returns during the 15 years of their existence. Some of the seedlings were found to produce fruit of very good quality: a type named Button seedling grown by a private grower has yielded large fruit of excellent taste with a purple skin and a small seed; tree No. 12/6 and tree No. 12/12 in the Acclimatization Garden yielded as follows; the former a Fuerte-like fruit in shape, of exceptionally good taste with a green skin and a mean weight of 300 grs., the latter a green-skinned, slender fruit of good appearance, fair taste and a mean weight of 400 grs. Budwood, from seedlings which produced very good fruit, will be grafted on various stocks in order to find their fruitfulness as budded trees.

A small group of West Indian seedlings grown from seed obtained in Chile proved to be very weak trees, frequently suffering heavy damage by frost, and yielding medium to low crops of fruit of good appearance but rather inferior quality. However, the importance of these trees lies in the fact that they gave seeds for rootstocks, which, as mentioned before, were used for trials carried out in the interior valleys.

DUKE—Mexican Race: Trees of this variety are large, very fine, symmetrical and wind resistant. They flower early and are partially self-fruitful, as, in contrast to other varieties, male and female organs of some of the flowers function at the same time of day. The fruits are elongated and rather small, with a green skin. The mean weight of the fruits from young trees is about 200 grams, while fruit from heavy yielding mature trees averages not more than 150 grs. Fruit quality is very good in spite of its relatively low oil content, 14.5% (one analysis only). The ripening season is from the end of July or the middle of August to the middle of September. In common with all avocado varieties under our conditions, yields vary greatly, but in this variety they tend to be relatively good. One tree in our grove produced an annual crop of 76 kgs. from its 6th to its 15th year. The only serious drawback to this variety is its susceptibility to the Mediterranean fruit fly. It has been profitable so far to bag the fruits, thus protecting them against the fly; non-protected fruit may be infested up to 100%. It is doubtful whether this measure could be carried out with profit in a commercial grove, hence before Duke can be grown in this country on a commercial scale, another method of fighting the fly will have to be found.

NORTHROP: Trees somewhat smaller than Duke. Fruit small (mean weight 100 to 150 grs.) with black skin and is similar in appearance to a small eggplant, a very common vegetable in Palestine. This similarity makes its marketing rather difficult. The quality of the fruit is high, its oil content was found to be 26%, the highest of all varieties tested so far. However, its keeping quality is very low, and over-ripe fruit has an exceptionally bad taste. The fruit ripens later than Duke, usually from the middle of September to the middle of October. Yields are lower than those of Duke, but hundreds of fruits per tree have been harvested in many places. Trees of this variety ' are badly attacked by thrips, taut on the other hand its fruit is much less susceptible to attack by the Mediterranean fruit fly than is Duke. This variety has its uses for the home orchard, but cannot be recommended for commercial plantations.

MEXICOLA: Trees never very strong and may be quite weak. Mexicola is the earliest variety in our collection to flower, usually beginning in winter, or even in late fall. Its fruit is very small, 50 to 150 grs. mean weight, with a black skin, a large seed, and very little flesh, of good quality. The fruit ripens in August. Although the trees are fairly to highly prolific, it seems very doubtful, owing to the difficulty in marketing its fruit, whether this variety will ever be grown commercially. However, it might be profitable to raise Mexicola as a source of seeds for the growing of rootstocks.

GANTER: We have only one tree of this variety. The tree is dwarfish, yields low, fruit small sized, green skin, but has a good oil content. This variety cannot be recommended for commercial planting.

PUEBLA: This variety is of such low productivity that in most cases it has been top-worked to other varieties.

CALIENTE: An upright, strong growing tree. Fruit purple, about 300 grs., ripens in September and October and may serve to supply the market after Duke. The fruit is attacked by the fruit fly, but to less extent than Duke.

FUERTE: Mexican-Guatemalan hybrid: This is the leading commercial variety in Palestine as it is in California, taut owing to its irregular bearing habit it is desirable in many districts in this country, as in California, to replace it by a more regular bearer. The tree grows very well here, forming a broad structure, which, although requiring wider spacing, makes picking easier. The quality of the fruit is unsurpassed and the consumers in Palestine have become so used to it that they regard it as a standard and judge all other varieties accordingly. The fruit is in season here from December till February, its mean weight is about 250 to 300 grs. and its oil content rises from about 19% at the beginning of the season to about 24% at the end. Although this variety is by far the most frequently planted, yield records are scanty and mostly unreliable. In 1936 a grove of 26 trees eight years old yielded 2886 fruits, single trees bearing from nil to 361 fruits. No other yield records from that grove could be obtained, but it is certain that, although good harvests were gathered from it in some years, especially in the last few seasons, wide fluctuation in the size of the annual crops occurred. In Mikveh Israel, 12 trees gave a mean yield of 90 fruits from their fourth to their eighth year. One year's yield was better than that of all other years together. In general Fuerte has proved to be an erratic bearer in this country, especially mature trees. Tree yields and the quality of the fruit of different trees, vary greatly even in the same grove. These variations may be due to the close planting practiced in this country and to other external influences, but it also seems probable that they may be due to the hereditary make-up of individual trees. Thus in choosing budwood it is advisable to take it from trees that, over a long period, have proved to be prolific and regular bearers of fruit of high quality. Parthenocarpic fruits, the result of defective pollination, were found on Fuerte trees in many parts of the country. These fruits are sausage-shaped, usually not more than 10 cm. long; they are edible but have no market value. Fruits of the Fuerte have not been attacked by the Mediterranean fruit fly.

LULA: One tree, introduced by a private grower in the coastal plain as Taft variety, seems to be a Lula and has been propagated as such. Trees grow well and yield very good crops. The fruit, which ripens in late winter, is somewhat larger than Fuerte and is rather attractive. However, the seed is very large and quality of the flesh poor. In spite of its good yields it is doubtful whether this variety should be grown for market.

SEEDLINGS: Two seedlings, which may be Guatemalan-Mexican hybrids, were found to bear valuable fruit. One of them bears fruit which resembles Fuerte but which ripens four to six weeks earlier. The other, with purple skin, roundish in shape, small seed and excellent taste, also ripens in late fall. If they prove to be of commercial value, they will be described later.

ANAHEIM: Guatemalan Race: This variety is characterized by a well developed but slender tree, narrow leaves and very thin branchlets. Because of the small size of the branchlets it was found more difficult to bud this variety than most others. On very light soils the Anaheim has not developed as well as the Duke or the Fuerte, but on most other soils its development was quite satisfactory. Fruit large, average weight 500 grs., oval to elliptical in shape, with a thick green skin, and of good appearance, easily sold on the market. Fruits which were picked in January or February were found to contain only 8 to 10 per cent of oil, and had rather a poor taste, while those picked in March or even April were found to contain 15 to 16 per cent oil and were of a very much improved quality. However, even the fruit picked at the latter date could not compare in quality with that of the Fuerte or Benik. Yields obtained from the Anaheim were fair to good, crops as high as 100 kgs. per tree were obtained. In Mikweh Israel four trees yielded a mean crop of 110 fruits per tree from the 5th to 9th season. The fruit has never been attacked by the Mediterranean fruit fly. Since it was found that the fruit of Anaheim is of good quality when picked late, and due to its reliable and regular yields (most regular bearer of all the Guatemalan race), this variety can definitely be recommended for general planting.

BENIK: The four trees of this variety which were imported by the Agricultural Research Station from California in 1934 developed very badly at first, but later improved, and are now large, fine and healthy. They started bearing in 1937. The fruit, which ripens from January to March, is purple, medium to large size (mean weight 350 to 450 grs.) and of excellent quality. By January its oil content is nearly 20%. On the other hand, the variety seems to come into bearing very late; the first commercial yield was obtained only in the 9th season. It was at first assumed that the original trees came into bearing late because of the difficulties of acclimatization, but it was found since that local trees budded to this variety behave in the same way. Yields in the last three seasons were fair to good—the general mean being 53 kgs. per tree per annum. In spite of the high quality fruit, it was at first doubtful whether Benik should be recommended for commercial planting, due to its very light yields. Even now it can only be recommended for experimental planting as, in addition to its tendency to come into bearing late, its marketing possibilities are doubtful since consumers seem to prefer green colored fruit.

NABAL: Introduced from California in 1934, this variety is characterized here by strong trees with very large and exceptionally broad leaves. The fruit is round in shape, medium to large in size (mean weight 400 to 500 grs.) with a thick green skin and a very small seed. The fruit ripens late in spring; (at the end of January its oil content was only 9% while in March it went up to 15%) and may safely be kept on the tree till April. In March and April fruit quality is very high. The trees came into bearing late, and from the 9th to the 11th year yielded an average crop of 31 kgs. per tree per annum. Alternate bearing habit is definitely pronounced; each tree has yielded much in one year and none in the following. By virtue of its high quality, late ripening and most attractive appearance, this variety is a favorite on the market. However, as till now, yields have been low, it can be recommended for trial only, but not yet for general commercial planting.

QUEEN: Introduced in 1934; the only tree which has grown is inferior to Benik and Nabal. For many years the tree flowered profusely but yielded only parthenocarpic fruits, but in the last two seasons began to yield normal fruits. The fruit is large (nearly 600 grs.), well shaped with a beautiful lustrous purple color, and of very fine quality. The 1943/44 crop was 23 kgs and the 1944/45 crop was 54 kgs. However, because of the comparatively low yields, its too large fruit and purple skin, it is doubtful whether it can be recommended for general commercial planting, but should be tried on a small scale and in home orchards.

DICKINSON: Introduced with Fuerte at an early date. Trees have been grown in a number of places and are strong and healthy. They yield fair to good crops. Fruit is mostly poor in quality, with a very thick skin and an extremely large seed. It usually ripens in spring. In spite of its good yields this variety cannot be recommended for planting because of its poor quality.

COLLINSON: Guatemalan-West Indian hybrid. This variety, which has been grown in this country in a number of places, has frequently been damaged by frost and has yielded badly. Two trees of this variety which were introduced from Florida in 1936, planted in an interior valley in a soil containing about 50% lime, and irrigated with water containing approximately 200 ppm chlorine, were the first to indicate the possibility of a healthy development of avocado trees under such conditions, and led to the use of West Indian seedlings as stocks. These two trees grew very well, flowered profusely, but for a number of years set no fruit. This unfruitfulness seems to be characteristic of the Collinson under these conditions and only partly due to lack of pollination as other varieties planted later flowered and set fruit normally. The Collinson cannot be recommended for planting in any district in this country.

WEST INDIAN RACE: The only tree of a named variety of this race— the Winslowson—was introduced a few years ago, but has not yet borne fruit.

Among the varieties mentioned above, those that can be recommended for planting are: Duke as a summer fruit, Fuerte as a winter fruit, Anaheim, Benik and Nabal as spring and early summer fruit. Anaheim is the best yielder, but for early picking its quality is much inferior to Benik. Benik is the best quality fruit for January and February, but its yields are erratic and consumers do not like its purple color. Nabal is the most attractive and, like the Anaheim, late ripening but far less prolific.

Propagation

Most nurserymen are of the opinion that the best seedlings are produced from seeds of Mexican seedlings or budded varieties of the Mexican race such as Mexicola, Ganter and Northrop. Duke produces weak seedlings, while Fuerte and the Guatemalan varieties produce fine seedlings, but at such an inconvenient time of year that they are usually not strong enough for budding in the first autumn. With the development of the avocado industry in Palestine, it has become the practice either to plant the seeds in

nursery row, or to transplant to it young seedlings which have been germinated in a seed box.

Most avocado plants sold by our nurseries until now were seedlings, however in the last few years budded trees have been offered for sale. Budding may be done at almost any time in summer and autumn, provided the stock is growing strongly, does not show any signs of disease or sunburn of the bark, and is at least as thick as a finger. The best time for budding different varieties in summer is according to the condition of the budwood. On the other hand, budding in the late fall, October or November, is suitable for all varieties, and the young nursery material, 13 to 14 months after planting, is then usually in best condition for budding. These months are also opportune for commercial nurserymen. Great care must be exercised in choosing bud-wood which should be as fresh as possible when used. On the other hand, good results are sometimes obtained with budwood cured for a considerable time before use.

Shield budding is the normal method and is completely successful. Cleft grafting is used in top-working old trees. It is much more difficult to successfully bud seedlings growing in tins than in nursery rows. Raffia is used for wraps and should be loosened and retied after three weeks, but not removed altogether. After the buds start growth, the stock should be cut back gradually. In the nursery the stems must be whitewashed to prevent sunburn. Budded trees should always be balled before transplanting, while seedlings, under specially favorable conditions, may be planted with bare roots.

Planting Distances

Usual planting distances of 5 by 5 meters practiced in this country for avocados are doubtless too small for full development of the tree. It is therefore proposed in future to plant avocado trees 6 by 6 meters, but it is not unlikely that greater distances (7 by 7 meters) will have to be adopted for varieties with spreading habits.

Irrigation

It is imperative to irrigate the avocado frequently, especially on light soils, as most of the roots are concentrated near the surface. Under similar conditions, the avocado should be irrigated more frequently than citrus or the mango. At the end of the rainy season special care should be taken to keep the top 30 cm. of soil from drying out so as to counteract as far as possible the detrimental effects on the flowers and young fruits on khamsin days which may occur in April or May, or even as early as March. Irrigation every two weeks is hardly commercially feasible, and, under most conditions, every third week should be sufficient.

Fertilization

It is observed that for full development and fruitfulness, large applications of fertilizer, especially of nitrogen in the form of barnyard manure, should be applied. No exact data can be given at this time.

Cultivation

As the avocado tree develops a very shallow root system and as most of the feeding roots are concentrated in the top 30 cm of soil, cultivation should be either avoided completely or at least reduced to a minimum. Wherever possible, in order to keep the top soil near the rootlets cool and moist, organic mulching should be practiced instead of mechanical cultivation. In mature groves the falling leaves serve as a mulching material and are sufficient for the purpose. In young plantings other suitable material should be added to the leaves.

Pruning

There is some controversy with respect to pruning avocado trees. It is maintained on the one hand that it is, or should be, possible to prevent trees from reaching a height which makes picking difficult, by suitable methods of regular pruning. In this country, at least till now, no method of pruning has as yet proved successful in this respect. It was found that after heading back the newly planted trees which are quite often not well balanced, compact growing varieties such as Fuerte and Duke are in no need of pruning other than removal of dead branches and cutting back low lying branches. The growing habit of slender and upright varieties was not materially affected by heavy pruning and training, and the picking of fruit was not made easier; but in some cases trees were damaged by sunburn after the tops had been removed by pruning.

Yields

Yield records are scarce and not always reliable. Fluctuations in yield of the same tree in different years and of different adjoining trees of the same variety are so considerable that to be of much value yield records must be based on a large number of trees and years. The strong yearly fluctuations in yield are partly due to climatic factors, e.g., the time, duration and strength -of the khamsins, and partly to the tendency to alternate bearing exhibited by some varieties. The following factors influence individual performance of trees within a variety: the composition of the variety of more or less fertile types, the rootstock, the soil, and possibilities of pollination.

A mean yield of 1000 to 1250 kgs. per dunam per year may be assumed to be normal for mature trees of Duke and Anaheim. The Fuerte is an unreliable and erratic bearer. A new variety which would as far as possible be similar to Fuerte in appearance and fruit quality, and at the same time a more regular bearer, would be a very important addition to our present collection of varieties and a great boost to the industry in general. It is very difficult to estimate yields of Guatemalan varieties other than Anaheim. They will probably come into bearing late, and after reaching full maturity yield no less than Anaheim or Duke. In general, sometimes a single and very strong tree may give as much as a thousand or even more fruits per year, but obviously no calculations can be based on such a figure.

Ripening Dates, Storage, Marketing

The avocado season begins in the middle of August to early September, with fruits of the Duke variety. Northrop, Ganter, Caliente are usually harvested at the end of Duke picking. No budded variety ripens in November, but some seedling fruits are harvested then. Owing to this temporary scarcity on the market, unripe Fuerte fruits are often marketed at that time as prices are naturally high. This is very undesirable for the industry as a whole as the quality of such fruits is very low, and it is therefore most important to find a variety suitable for this period. The seedlings mentioned above are under observation, and one or more of them may prove of value. The Fuerte can be picked and marketed from December to February. Fruits of Guatemalan varieties can normally be picked at the end of the Fuerte season, but are sometimes harvested as early as January or even December, and most of them come to market before they have reached proper maturity and best quality. Their harvest may continue over a period of three or four months so that it will be possible to market fruits of these varieties from February till May.

From the foregoing it will be seen that avocado fruits are available during nine months of the year. The gap in supply between May and August may be filled partly by storage of fruit, a possibility not yet sufficiently explored, but it is not expected that this gap will be filled completely.

As there have been many cases of avocado fruits marketed before they reached proper maturity and best quality, it was necessary to find out the best picking time for each of the important varieties, and this has been done by observations carried out over a number of years. As a result, the following easily recognizable signs can be provided to growers in order to assist them in selecting mature fruit on the tree.

- (a) Fruit with purple skin—the change in color of the skin is usually the best sign of maturity.
- (b) Fruit with green skin—the change in the color of the fruit stalk from dark to light green or yellowish green and a similar change in the color of the skin of the fruit. In some varieties the loosening of the seed in its cavity is also a sign of maturity.

The oil content of the fruits of the different varieties in various stages of maturity was measured by the Division of Chemistry and by the Fruit Products Laboratory of the Agricultural Research Station. The results led to the following conclusions: Fuerte should be picked with an oil content of at least 20%, not before late December or January. Benik can be picked from the end of January, when its oil content is about 18%, till March or April, when its oil content will be not much higher than 20%. Nabal and Anaheim should not be picked before the end of March or April, when their oil content will have reached about 15%, but not in February because their oil content is then less than 10%.

Fruits which are picked fully mature, packed and transported with ordinary care, have reached local markets in excellent condition and have ripened well within the time needed for distribution. Fruit picked too early may remain in the retailer's shop for a very long time and finally soften without being really ripe; fruit picked too ripe will sometimes soften during distribution.

Due to their short supply on the market, the price of avocado fruits, even those not up to standard, has been high. Most growers are loath to hold their fruit on the trees till properly mature because of the small number of trees in their possession and the danger of frequent thefts. Because of these conditions most growers tend to pick their fruit too early. However, in the long run, it would pay growers to bear increasing costs of watching as, sooner or later, with the increase of volume of fruit, the consumer will reject unripe and tasteless fruit.

Avocado fruits are picked with clippers and a suitable picker has been devised for reaching those fruits which hang too high on the tree. With larger plantations, better implements should be secured in order to reduce picking costs, towards the time when greater available volume of fruit will reduce the price.

No storage trials under controlled conditions have been carried out so far. A start has been made and this work will continue in the near future.

The following are prices received for avocado fruits of all varieties. Before the war growers received LP.1.—for 100 fruits of Duke, L.P.1.500 for 100 Fuerte and LP.2. — and more for 100 fruits of the Guatemalan varieties. During the war, prices rose to about four times these figures. Even pre-war prices, which were low in comparison to those received in wartime, were too high and prevented the fruit from reaching wide circles of the population. Since the avocado should be considered as a nutrient rather than as a luxury its price should be relative to that of its oil content and comparable to that of butter. To achieve this, the volume of fruit available on the market and yield per unit should be increased as much as possible.

Insect Pests and Diseases

The most serious pest infesting the avocado in Palestine is the Mediterranean fruit fly. Up to now, no infested fruit of Fuerte or any of the Guatemalan varieties has been found, probably due to their thick skin. The percentage of infestation of some Mexican varieties is not high enough to represent serious danger. Duke is seriously infested, sometimes up to 100%. The only means of control up to now used on a large scale has been to enclose each fruit in a small paper bag, and this has been entirely effective. With falling prices, this method may soon become too costly. A more economical method must be found, or it may soon become unprofitable to grow these varieties which are highly susceptible.

The thrips, **Heliothrips haemorrhoidalis**, is on the way to become a major pest in avocado groves, especially where trees are planted so close together as to become crowded. Thrips do not affect the development of the tree, or the eating quality of the fruit, but by causing extensive skin blemishes spoil the appearance of the fruit. Other insect pests, several species of scales, have been noted occasionally, but no damage has been recorded.

Anthracnose caused by **Colletotrichum sp.** has been found on leaves and occasionally on fruits. **Diplodia** has been found on dead twigs, but it is doubtful whether these fungi are primary or secondary parasites. Young plants have been killed by **Rhizoctonia and Fusarium**. Properly picked, the avocado has not so far been damaged by fruit rots.

Stems of young avocado trees in groves are very frequently damaged by sunburn. Severely sunburned trees are crippled for life, while less severe sunburn on seedling root-stocks will render it impossible to bud them successfully. In some varieties tipburn of the leaves, most probably caused by khamsin winds, is fairly common, and in some cases may be severe.

According to external characters, it seems that the sunblotch virus prevalent in California is also present in some varieties in this country; however, this has not yet been substantiated scientifically. Young infected trees are severely crippled by this virus, but almost no damage has been found on mature trees. Fruit on affected trees have sunken areas, at first yellow and later turning brown. Seriously affected fruits are not marketable. No bud-wood should be taken from diseased trees and it would in most cases be best to destroy them altogether.

Pollination Behavior

Avocado flowers are perfect but are normally not self-pollinating. Each flower opens twice, at the first opening the stamens are still unripe while the stigma stands upright and is receptive; at the second opening the stamens shed their ripe pollen but the stigma has already withered. Under well-balanced climatic conditions all flowers of a single tree open simultaneously both in the first and second opening. Thus flowers of the same trees cannot pollinate each other, and as all trees of a given variety are in reality parts of one tree, they behave in the same way. Therefore, within a variety, no fruit set is normally possible through self-pollination. In addition, all avocado varieties belong to one of two existing groups as regards the opening of their flowers. Members of the same group cannot pollinate each other. The order of the flowering of these two groups are as follows:

Group A. First opening in the forenoon—stigmas receptive, pollen unripe. Second opening in the afternoon of the following day—stigmas withered, stamens shedding ripe pollen.

Group B. First opening in the afternoon—stigmas receptive, pollen unripe. Second opening in the forenoon two days later—stigmas withered, stamens shedding ripe pollen.

However, it should be noted that in Palestine all the varieties do not flower at the same time. The Mexican varieties flower much earlier than the Guatemalans, and their flowering time is usually over before that of the latter even begins. Most of our early and medium flowering varieties belong to group B. But as those varieties are quite often grown by themselves with fair results, it seems probable that under our climatic conditions of very unstable weather during early spring the flowering habit of the avocado outlined above breaks down rather frequently, and then self-pollination becomes possible. As a matter of fact, observations have shown that on trees of Duke and Ganter and sometimes even Fuerte, while most of the flowers may behave normally as described above, a considerable minority will show the opposite behavior. This, however, does not mean that better yields may not be obtainable even from these varieties by the interplanting of trees of group A. Of the later flowering varieties no such deviation from the normal flowering habit has been found, and fruit set is absolutely

dependent on cross pollination. Anaheim and Fuerte seem to be good cross pollinators, as do Benik, Nabal, and Queen. The latter group planted together proved to be quite prolific although, due to youth or climatic conditions, they failed to yield at the beginning.

Some varieties such as Fuerte and Queen have sometimes produced seedless fruit, probably because of lack of pollination. Such fruits are sausage-shaped and very small, and although they are unfit for market, they ripen properly and are quite edible.