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II. THE AVOCADO

The avocado of horticulture is divided into three races, named, according to their country of origin: the Mexican, the Guatemalan and the West Indian. The Mexican and the Guatemalan are highland races; the West Indian has its origin in the tropical lowlands. Until recently the Mexican race was regarded as *Persea drymifolia* Cham. and Schlecht, and both the Guatemalan and the West Indian races were included in *Persea americana* Mill. However, according to the latest investigations, all horticultural types of avocado are to be included into a single species - *Persea americana* — and the name *Persea drymifolia* has become obsolete.

The three races are easily distinguishable by the scent of their leaves, the thickness of the peel and the time of ripening of their fruits, as shown in the following key:

| Race | Scent of leaves | Thickness of peel of fruit | Time of ripening |
|-------------|-----------------|----------------------------|-----------------------------|
| Mexican | Anis | Thin | 5—7 months after blossoming |
| Guatemalan | None | Thick/woody | 9—12 " " " |
| West Indian | None | Medium/leathery | 7—8 " " " |

In its countries of origin the avocado has, since ancient times, constituted an important part of the diet of the native population. In contrast to the mango it did not spread outside its native habitat until the eighteenth century, and even then only a few trees were planted, first in Florida and later in California. Only at the end of the last century, or even at the beginning of the present one, did avocado growing become commercially important in these two states. Since then, avocado culture has been developed, both in California and Florida, into a thriving and important industry and almost all scientific knowledge on avocado growing has come from one of these states, which now serve as secondary centres of origin of avocado varieties.

Development of avocado culture in the old world was even slower than in the new. Although avocado trees may be found in most subtropical and tropical countries of the old world, the crop produced in these countries is small and commercially not important. Very small quantities of avocado fruits are imported annually into European countries, mainly into England, from Madeira, South Africa and Central America. Most of the fruit imported into Europe was not of high quality and nowhere in Europe did it become part of the normal diet of the population.

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.

2. *Optimal climatic requisites.*

Optimal 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 -4°C ., Guatemalan varieties compare with the Lemon, and West Indian varieties are, if anything, more tender even than the lime, showing considerable damage already at -2°C . 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 favourable, to the set of the avocado fruit. In regions of moist summers fruit-skin diseases can seriously harm both avocado and mango fruits. Where good irrigation facilities are available, total precipitation is not of very great importance, but in regions of summer rainfall where avocado can be grown without irrigation, production costs tend to be lower. In regions where rainfall is insufficient or completely absent during part of the year, liberal application of water should be made. The water duty of avocado trees is higher than that of citrus and most other fruit trees.

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 favourable 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 only. 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 severeness 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 avocado yields. On the other hand, seasons with few, slight or very late khamsins are favourable for the production of a good crop (Fig. 17). 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.



Fig. 17. Avocado: Flowers and Young Fruits.

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 medium clay content have so far proved to be best suited to avocado culture in this country. Avocado can also be grown successfully on the brownish red soils of type B if they are well drained. Heavy soils of type C 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. Fine 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.

3. Varieties.

Most avocado trees grown in Palestine are seedlings, mainly Mexican, but there are also some Guatemalan and a few West Indians 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 9 metres and their mean trunk girth somewhat over 100 cm. 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 fruits 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 (Figs. 18, 19).

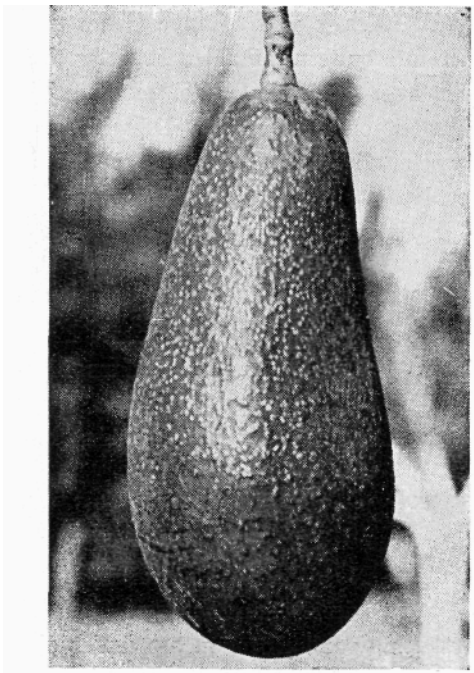


Fig. 18. Avocado: Fruit of Seedling 12.12. Half Natural Size.

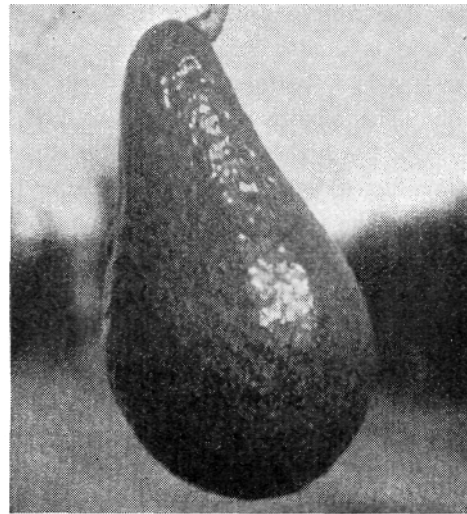


Fig. 19. Avocado: Fruit of Seedling 12.6. Half Natural Size.

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.

Some well-known Californian varieties are described below:—

Mexican race. Duke; The trees of this variety are large, very fine, symmetrical and wind-resistant. The trees flower early and are partially self-fruitful, as, in contrast to other varieties, male and female organs in some of the flowers function at the same time of the day. The fruits are elongated and rather small, with a green skin. The mean weight of the fruit from young trees is about 200 grs, 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 obtained vary greatly, but in this variety they tend to be relatively good. One tree in our grove produced a mean annual crop of 76 kgs. From its 6th to 15th year. It may be assumed that normal trees in other groves have yielded crops of similar size. 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 infected up to 100%. It is doubtful whether this measure could be carried out with profit in a commercial avocado grove, hence before Duke can be grown in this country on a large scale, another method of fighting the fruit fly will have to be found.

Northrop: The trees of this variety are somewhat smaller than those of the Duke. The fruit is small (mean weight — 100-150 grs) with a 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 regularly in many places. Trees of this variety are rather badly attacked by thrips, but 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 as its fruit is not larger and has no better keeping qualities than the fruit of the average seedlings, it cannot be recommended for commercial plantations.

Ganter: There is only one tree of this variety in this country, introduced from California in 1943. The tree is dwarfish in size and its yields have never exceeded 20 kgs. per annum. The fruit is rather small (mean weight about 150 grs), with a green skin, and is of good quality. The fruits ripen in the second half of September. This variety cannot be recommended for commercial plantation as it seems to show no particular distinction.

Puebla: This variety is of such low productivity in this country that, in spite of the high quality of its fruits and the possibility that it may be desirable as a pollinizer for Fuerte, in most cases it had to be top-worked.

Mexicola: The trees of this variety are never very strong and may even be quite weak. Mexicola, the earliest variety in our collection to flower, usually starts flowering 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,

thus filling any scarcity of seeds on the market, which might arise out of the budding of most seedling trees.

Caliente: This variety is characterized by an upright and, as a rule, quite strong tree. The fruit is pear-shaped, medium in size (mean weight about 300 grs) and its skin is purple coloured with light stripes. The seed is rather small and the quality of the flesh good. The fruit ripens in September and October and may serve to supply the market after Duke. The fruit is attacked to some extent by fruit fly, although less severely than the Duke. The variety is of interest for this country but it is not yet possible to form a definite opinion as to its market value.

Mexican—Guatemalan Hybrids. — Fuerte: This is the leading commercial variety in Palestine as it is in California, but 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 as with Guatemalan varieties. 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—300 grs and its oil content rises from 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 1938 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 eighth year. One year's yield was better than that of all other four 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, probably 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. Fuerte fruits have not till now been attacked by Mediterranean fruit fly (Figs. 20, 21, 22).

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 of this variety 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 the quality of the flesh poor. In spite of its good yields it is very doubtful whether this variety should be grown for the market.

Seedlings: Two seedlings, which may be Guatemalan-Mexican hybrids, were found to bear valuable fruit. One of them bears fruit which resembles the Fuerte but which ripens

four to six weeks earlier. The other, with purple coloured skin, roundish in shape, small seed and excellent taste, also ripens in late fall. Both are worth propagating experimentally. If they prove to be of commercial value, they will be described at a later date.

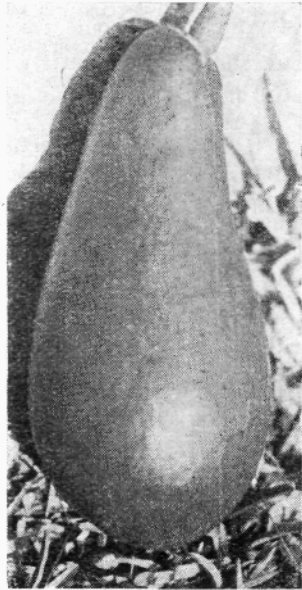


Fig. 20. Avocado: Fruit of Fuerte Variety. Half Natural Size.

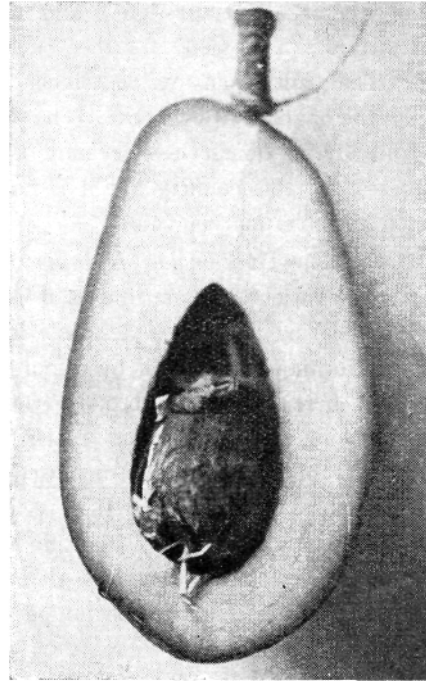


Fig. 21. Avocado: Fruit of Fuerte Variety, Cut Open. Half Natural Size.

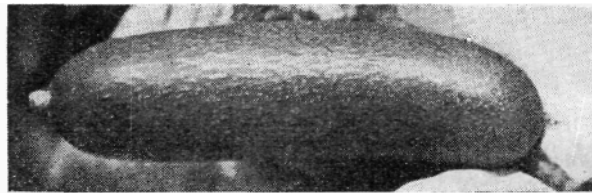


Fig. 22. Avocado: Parthenocarpic Fruit of Fuerte Variety. Natural Size.

Guatemalan Race. — Anaheim: This variety is characterized by a well-developed but slender tree, narrow leaves and very thin branchlets. Because of these branchlets it was found more difficult to bud this variety than most others. On very light soils the Anaheim tree has not developed as well as the Duke or the Fuerte, but on most other soils its development was quite satisfactory. The Anaheim fruit is 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 usually picked in January or February were found to contain only 8 - 10% fat and had rather a poor taste, while those picked in March or even April were found to contain 15 - 16% fat and were of a very much improved

quality. However, even the fruit picked at the latter date could not compare in quality to that of the Fuerte or Benik. Yields obtained from the Anaheim variety were fair to good, crops as high as 100 kgs. per tree were obtained. In Mikweh Israel 4 trees yielded a mean crop of no fruits per tree from their 5th to 9th season. The fruit has never been attacked by the Mediterranean fruit fly. Since it was found that the fruit of the 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 (Figs. 23, 24).

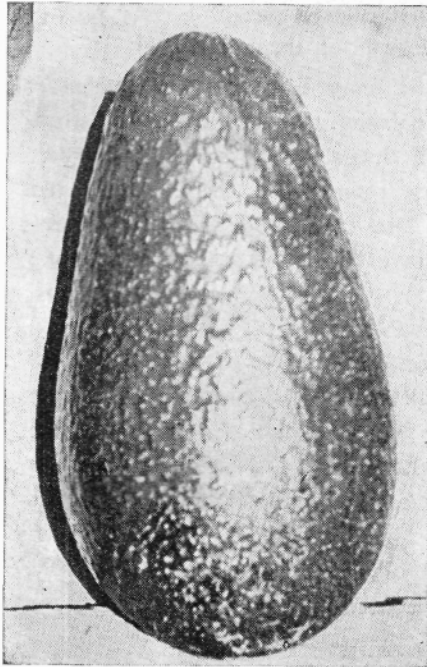


Fig. 23. Avocado: Fruit of Anaheim Variety. Half Natural Size.

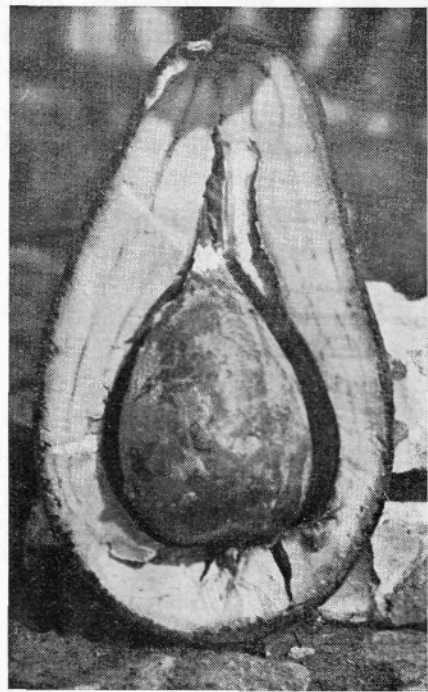


Fig. 24. Avocado: Fruit of Anaheim Variety, Cut Open. Half Natural Size.

Benik: The 4 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 of a purple coloured skin, medium to large in size (mean weight 350—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 ninth 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 manner. 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 the Benik variety 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 coloured fruit (Fig. 25).



Fig. 25. Avocado: Fruits of Benik Variety. One Sixth Natural Size.

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—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 ninth to the eleventh year yielded an average crop of 31 kgs per tree per annum. Alternate bearing habit is definitely pronounced in this variety; each tree has yielded much fruit in one year and none at all 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 too low, it can be recommended for trial plantation only, but not yet for general commercial planting (Fig. 26).

Queen: This variety was also introduced in 1934. The only tree which has grown from it is inferior to those of Benik and Nabal. It is characterized by a good framework with very drooping branches. For a number of years this tree had flowered profusely but had produced only a few parthenocarpic fruits, but in the last two seasons it began to yield normal fruit. In 1943/44 the crop amounted to 23 kgs. and in 1944/45 to 54 kgs. The fruit is large (mean weight nearly 600 grs), well-shaped with a beautiful lustrous purple colour and of very high quality. However, because of the comparatively low yields of this variety, its too large fruit and purple coloured skin, it is doubtful whether it can be recommended for general commercial planting, but it should be tried on a small scale and may be worth planting in home orchards (Fig. 27).

Dickinson: This variety was introduced together with the Fuerte at an early date. Trees of this variety grown in a number of places were found to be strong and healthy, and have yielded fair to good crops. The fruit, which is mostly poor in quality, is round, small

to large, with a very thick skin and an extremely large seed; it usually ripens in spring. In spite of its rather good yields, this variety cannot be recommended for planting, because of its very low quality.

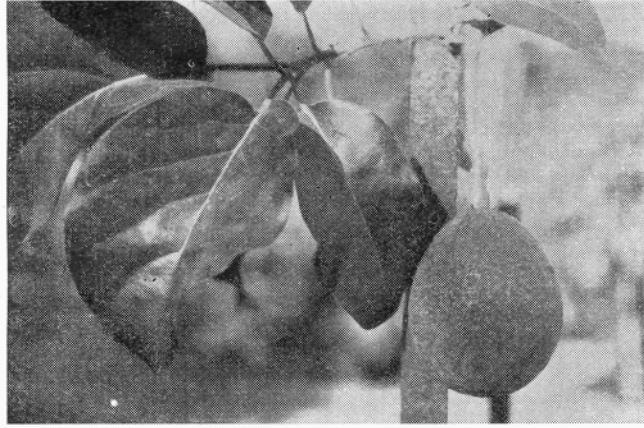


Fig. 26. Avocado: Fruit of Nabal Variety. Fourth Natural Size.



Fig. 27. Avocado: Fruit of Queen Variety. Half Natural Size.

Single trees of a number of other varieties which are grown in this country will not be mentioned here.

The Lyon variety, which was famous in California at one time, was found to be extremely dwarfish and quite unproductive.

Guatemalan West Indian Hybrids. — Collinson: This variety, which is grown in this country in a number of places, has frequently been damaged by cold or frost and has always yielded badly. Two trees of the variety, which were introduced from Florida in 1936, planted in the 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 varieties as stocks. The two trees grew very well, flowered rather profusely, but for a number of years set no fruit. This unfruitfulness seems to be characteristic to 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 therefore be recommended for planting in any district (Fig. 28).

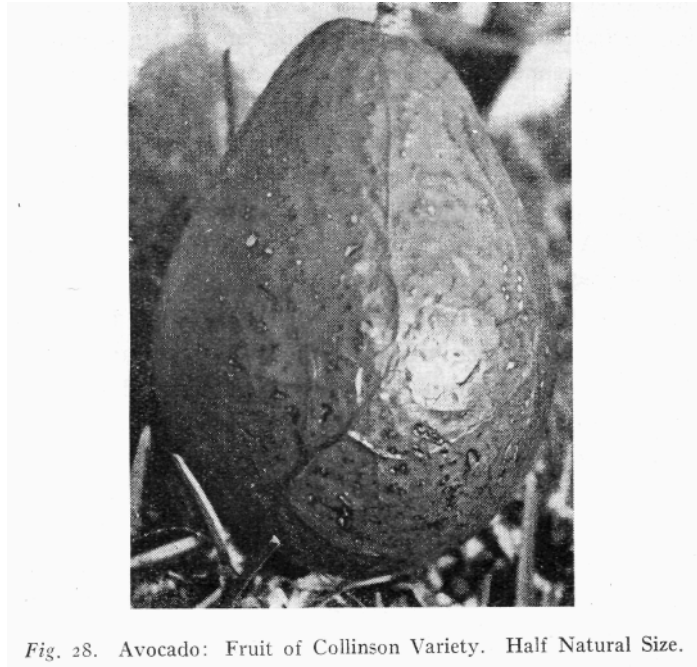


Fig. 28. Avocado: Fruit of Collinson Variety. Half Natural Size.

West Indian Race. — The only tree belonging to a named variety of this race — the Winslowson -was introduced a few years ago and has not yet started bearing fruit.

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

4. Propagation.

Avocado seeds keep much better than mango seeds, but it is usual and advantageous to sow them shortly after taking them out of the fruit. Most nurserymen are of the opinion that the best seedlings are produced from the seeds of Mexican seedlings or from those of budded Mexican varieties like Mexicola, Northrop or Ganter. Duke seeds seem to produce weak seedlings, while Fuerte and seeds of the Guatemalan varieties,

although producing fine seedlings, must be sown at an inconvenient time and are usually not strong enough for budding in the first autumn. Until now it has been customary to sow single seeds half covered with soil in large pots, transplant the young seedlings into petrol tins and sell the seedlings in the tin a year to three years later. This method is advantageous as the potted plants can be transplanted any time during the year. Its disadvantages are: the formation of an insufficiently developed root system and a thin whip like long stem, which under excessive irrigation can be as high as 1.5-2 m. Plants with such stems will certainly fail to develop in the orchard. A good nursery plant should be medium thick and from 60-100 cm high.

With the development of the avocado industry in Palestine, it has become the practice either to sow the seeds in the nursery row or to transplant to it young seedlings which are germinated in a seed box. The nursery seed-bed should be covered with branches, and its soil should be suitable for balling the transplants. It is almost certain that as the avocado industry develops the latter method will completely replace the former.

Most avocado plants sold by our nurseries until now were seedlings, however in the last few years the first budded trees were offered for sale, and it is strongly recommended that for commercial purposes budded trees only should be sold by the nurseries, and seedlings should be clearly marked as stocks. 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 varies in summer 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, 13-14 months after sowing, is then usually in best condition for budding. These months are also opportune for commercial nurseries. Budwood may also be taken from Guatemalan varieties in spring before they start to flower and from Mexican varieties in early summer after flowering and hardening of the young growth. Great care must be exercised in choosing budwood, which should be as fresh as possible when used. On the other hand, good results were sometimes obtained with budwood cured for a considerable time so that all the weak eyes had dropped before budding.

Shield budding is the normal method and is completely successful. Cleft grafting has been successfully used, especially in top-working. If the stocks are in a good condition and budwood is chosen carefully, there is no difficulty in obtaining a commercial stand of budded avocado trees in the nursery. It is much more difficult successfully to bud plants in tins than those grown in the open nursery. About three weeks after budding the raffia should be loosened and re-tied but not removed altogether. The stock should be cut back gradually in spring and the stump should be removed as early as possible after the growth from the bud has hardened at the base. In the nursery the stem must be white-washed and no branching should be allowed below 80 cm. Budded trees should always be balled before transplanting while seedlings, under specially favourable conditions, may be planted with bare roots.

At the beginning of this chapter it was stated that Mexican varieties supply the material most suitable for rootstocks in the nursery. This does not necessarily mean that the best trees in the orchard are budded on Mexican stocks. Although stock performance in the field is being investigated, no definite statement on the suitability of rootstocks and on

the stock scion compatibility can yet be made, as regular stock trial plots are only now in preparation.

5. Orchard Management and Yields.

Statements made above regarding lack of reliable information on cultivation practices for the mango apply equally to the avocado.

Planting Distances. Usual planting distances of 5x5 m. practiced in this country for avocado, are doubtlessly too small to allow full development of the tree. It is therefore proposed in future to plant avocado trees at a distance of 6 x 6 m, but it is not unlikely that greater distance (7x7 m) will have to be adopted for varieties with spreading trees.

Irrigation. It is imperative to irrigate the avocado frequently, especially on light soils, as most of the roots are concentrated in the uppermost layer of the soil. All conditions being equal, the avocado should be irrigated more frequently than the 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 of the khamsin days which may occur in April and May, or even as early as March. The length of the interval between irrigations should be determined by climatic conditions and type of soil. Thus, although irrigation every two weeks which was tried in one grove might be beneficial, especially on light soil, it seems doubtful whether it can be commercially feasible.

Under most conditions irrigation every third week should be sufficient for mature avocado trees.

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 supplied. No exact data can be presented at this stage.

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

Pruning. There is some controversy about the question of pruning avocado trees. It is maintained on the one hand that it is, or should be, possible to prevent trees from growing to 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 the Fuerte and the Duke, are in no need of pruning other than removal of dead branches and cutting back of low lying branches. The growing habit and shape of slender and upright growing 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 removal of the tops by pruning.

Yields. As mentioned before, yield records are scarce and not always reliable.

Fluctuations in yield of the same tree in different years and of different 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, i.e. the time, duration and strength of the khamsins, and partly to the tendency to alternate bearing definitely exhibited by some varieties. The following are the factors influencing individual performances of trees within a variety: the composition of the variety of more or less fertile types, the rootstock, the soil and possibilities for pollination.

A mean yield of 1000 to 1250 kgs per dunum per year may be assumed to be normal for mature groves of Duke and Anaheim trees. Yields obtained from the Northrop would probably not be lower, however due to its commercial shortcomings its further planting will be discontinued. The Fuerte is an unreliable erratic bearer. Trees may yield good crops in some years and very poor crops in others. A new variety which would as far as possible be similar to Fuerte in fruit quality and at the same time be a more reliable bearer, would be a very important addition to the present collection of varieties and a great boost to the industry in general. It is very difficult to estimate yields of other Guatemalan varieties apart from Anaheim. They will probably come into bearing late, and after reaching full maturity may yield no less than Anaheim or Duke. In general, sometimes a single and very strong tree may give as much as thousand or even more fruits per year, but obviously no calculations can be based on such a figure.

6. *Ripening dates, picking, 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 the 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 these fruits is very low, and it is therefore most important to find a suitable variety for this period. The seedlings mentioned above are under observation, and one or more of them may prove suitable. The Fuerte can be picked and marketed from December till February. Fruits of Guatemalan varieties can normally be picked after the end of the Fuerte season, but are sometimes harvested as early as January or even December, and most of them come to the 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 to 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, the end of the Guatemalan varieties and the beginning of the Mexican varieties respectively, 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.

Avocado fruits of most varieties can be harvested and stored for ripening over comparatively long periods, namely a few weeks for Mexican varieties and a few months for Fuerte and the Guatemalan varieties. Thus, if the quality of the fruit is not taken into consideration, harvesting can be carried out as a matter of convenience. On

the other hand fruit which is picked too early, before it is fully mature on the tree, will soften and become edible but will be lacking in oil content and usually in taste; fruit which is left on the tree till it is fully ripe will be of excellent quality and taste but will not keep and will be difficult to bring to the market. 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 every one of the important varieties, and this was done by observations carried out over a number of years. As a result of these observations, the following easily recognizable signs can be provided to growers in order to assist them in picking out the mature fruit on the tree:

(a) Fruit with purple-coloured skin — the change in colour of the skin, from green to purple, is usually the best sign of maturity.

(b) Fruit with green-coloured skin — the change in the colour of the fruit stalk from dark to light green and later to yellowish green, and the change in the colour of the skin of the fruit from a dull to a yellowish green. The change in the colour of the skin is due to the development of yellow lenticels. In some varieties the loosening of the seed in its cavity is also a sign of maturity.

The oil content of fruits of Guatemalan varieties and of Fuerte in various stages of maturity were measured by the Division of Chemistry and by the Fruit Products Laboratory of the Agricultural Research Station. The results which were compared with the changes in the fruit described above led to the following conclusions: Fuerte fruits should be picked, with a fat content of at least 20%, not before late December or January. Benik can be picked from the end of January, when its fat content is about 18%, till March or April when its fat content will be not much higher than 20%. Nabal and Anaheim should not be picked before the end of March or April, when their fat content will have reached about 15%, but not in February because their fat 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. On the other hand fruit picked too early may remain in the retailers 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. Furthermore, most of the growers are loath to keep their fruit on the tree too long as the small number of trees in their possession allows for frequent thefts. Because of these conditions, most growers tend to pick their fruit too early. However, in the long run, it would pay the growers to bear increasing costs of watching as, sooner or later, when the volume of available fruit will increase, the consumer will reject unripe and tasteless fruit.

Avocado fruits are picked with clippers and a suitable picker has been constructed for those fruits which hang too high on the tree. However picking costs have been fairly high. 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 its price.

No storage trials under controlled conditions have been carried out so far. A start has been made and the work will continue in the near future. Fruits picked at the proper stage may be kept in ordinary storage for three weeks.

The following are prices received for avocado fruits of all varieties. Before the war, growers received LP. 1. — for 100 fruits of Duke, LP. 1.500 For 100 Fuerte and LP. 2. — and more for 100 fruits of the Guatemalan varieties. During the war, prices went up to about four times these figures. Even pre-war prices, which were low in comparison to those received in war-time, 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 a luxury fruit its price should be relative to that of its fat 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 insect pest infecting the avocado is the Mediterranean fruit fly. No infected fruit of the Guatemalan varieties and of Fuerte has been found till now, probably due to their thick skin. Even though the percentage of infection of some Mexican varieties was not high enough to represent serious danger, fruits of other varieties, especially those of the leading variety Duke were infected up to 100%. The only measure of control which till now was used on a large scale and was found to be entirely efficient was the bagging of every single fruit in a paper bag. Naturally this method is costly and, with falling prices, might easily be too costly. A more economical method of control must therefore be found or, alternatively, a position might be attained where cultivation of susceptible varieties will not be worth while.

The Thrips *Heliethrips haemorrhoidalis* is on the way to become a major pest in avocado groves, especially where trees are planted too close together and become too crowded. The thrips do not affect the development of the tree or the eating quality of the fruit, but cause extensive skin blemishes and spoil the appearance of the fruit; although slightly damaged fruit may still be sold on the market, severely damaged fruit is not fit for sale.

Other insect pests, mainly a number of species of scales, have been found occasionally on avocado leaves, but no damage has been recorded.

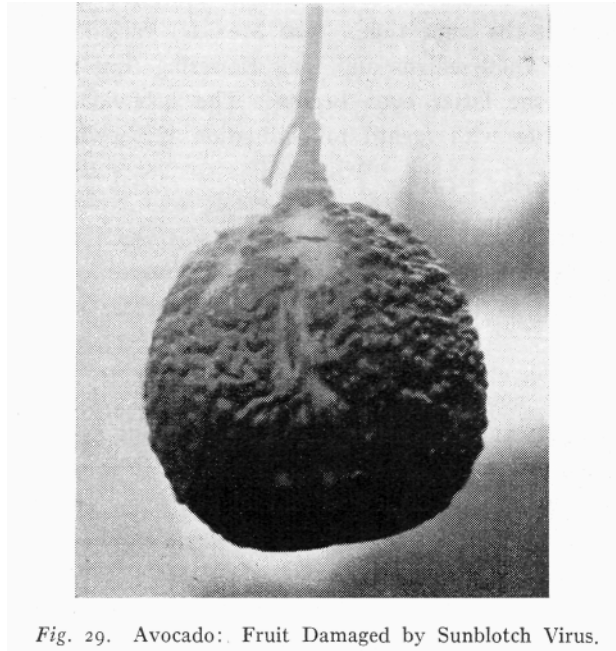
Anthraxnose caused by *Colletotrichum* has been found on leaves and occasionally on fruits. Diplodia has been found on dead twigs but it is doubtful whether these fungi are primary or secondary parasites, attacking organs which were damaged by climatic factors. Young plants have been killed by *Rhizoctonia* and *Fusarium*.

Properly picked fruit has not, till now, been observed to be seriously damaged by fruit rots. However, with growing quantities of available fruit and with trial export shipments, this problem will require constant attention.

Stems of young trees in avocado groves are very frequently seriously damaged by sunburn. Severely sunburnt trees are crippled for life, while less severe sunburn on the bark of young rootstocks will render it impossible to bud them successfully. In some varieties tipburn, most probably caused by hot dry winds, is fairly common and sometimes even 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 in mature trees. Sunken areas which are at first yellow and then usually turn brown are noticeable — to a higher or lesser percentage — on fruit from affected trees. Severely affected fruits are not marketable. No budwood should be taken from diseased trees and it would in most cases be best to destroy them altogether. The virus may be disseminated through crossing roots of neighboring trees (Fig. 29).



Pollination Behaviour. 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 in the second opening. Thus flowers of the same tree 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 flower; members of the same group cannot pollinate each other.

The order of flowering of the two groups is 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. The behaviour of the more important varieties with regard to pollination is shown below.

| <i>Time of flowering</i> | <i>Group A</i> | <i>Group B</i> |
|--------------------------|---|------------------------|
| Early (March) | Puebla | Duke, Northrop, Ganter |
| Medium (April) | Lula | Fuerte |
| Late (May) | Anaheim, Benik, Dickinson, Collinson | Nabal, Queen, Lyon |

It will be noted from this table that most of our early and medium flowering varieties belong to Group B. But as those varieties are quite often grown by themselves with at least 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 or Ganter and sometimes even Fuerte, while most of the flowers may behave normally as described above, a considerable minority will show the opposite behaviour. This, however, does not mean that better yields will 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 pollinizers, as do Benik, Nabal and Queen. The latter group planted together proved to be quite prolific although, probably 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.