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May 1983

AVOCADO PRODUCTION & MARKETING



COOPERATIVE EXTENSION SERVICE / COLLEGE OF THE VIRGIN ISLANDS



AVOCADO PRODUCTION & MARKETING

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*Recipes tested by C.V.I. Home Economics Program and are taken from their publication *Native Recipes*, Extension Bulletin No. 1.

FOREWORD

With the phasing out of the sugar cane industry as the island's major cash crop, the past two decades have seen much effort made to diversify the agricultural sector of the economy to include food crop and livestock production. However, various internal and external factors have hindered this transition. Since the 1960's when the last of the sugar cane crop was harvested, the people of the Virgin Islands have attempted to develop an appropriate substitute to replace this sugar industry or at least to increase self-sufficiency in food production. The people's faith in the basic role which agriculture can play in the overall development of our community has been the main contributing factor in rekindling the effort to increase local food production.

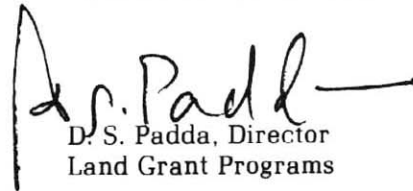
Water continues to be the major constraint of agricultural production. The other is unavailability of land at affordable prices. However, recent action by the government to make land and other incentives available to the prospective farmers has helped renew hope for expanding the agriculture industry of the islands.

For agriculture to be acceptable, it must be both productive and a preserver of our natural resources. The Cooperative Extension Service with its research capability can help our

farmers achieve both of these objectives. To meet the various needs of our part-time and commercial farmers, the Extension Service has published many fact sheets and farmers bulletins. This publication, *Avocado Production and Marketing* falls in the latter category.

This bulletin covers the entire spectrum of production and marketing of avocados. It is written by a team of specialists who possess an excellent background in their areas of expertise. I am very pleased that these three capable scientists have joined together to compile this package of information which is so vital to our farming community.

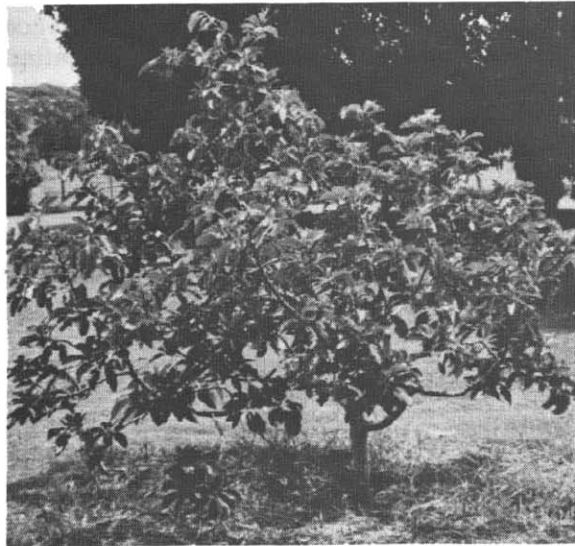
Avocado is a popular tropical fruit with great potential for expansion in the Virgin Islands. The climate of the three islands can profitably support avocado orchards. I urge all the Virgin Islands farmers and gardeners to use the information provided in this bulletin. We welcome any comment you feel might assist us in increasing local food production.



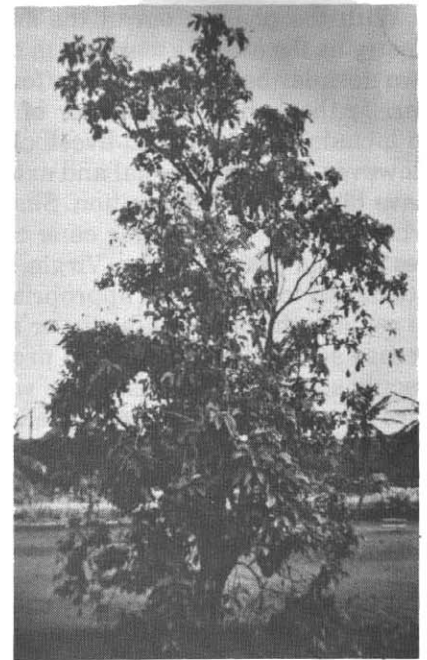
D. S. Padda, Director
Land Grant Programs

FIGURE 1.

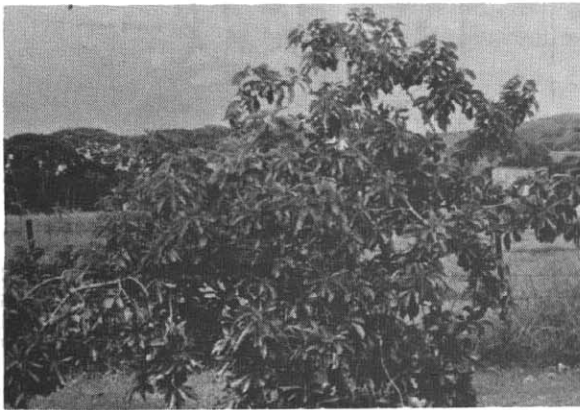
Avocado trees showing
different conformations
(a) Low, symmetrical;
(b) Low, spreading;
(c) Large, spreading;
(d) Tall, upright.



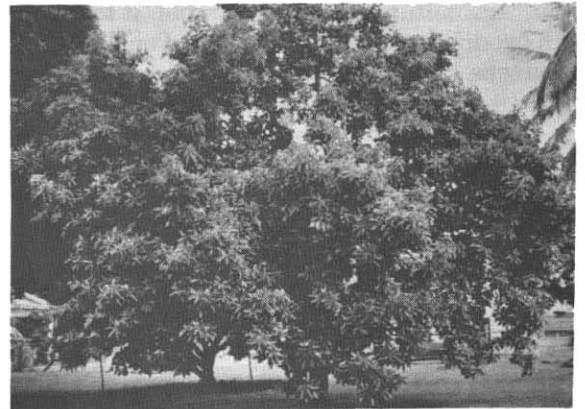
a



d



b



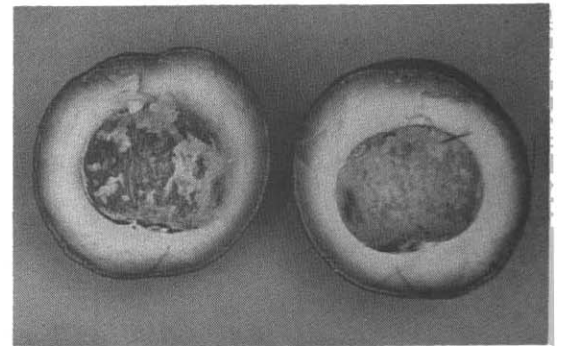
c

FIGURE 2.

Representative of
pyriform shaped
fruit is "Lula" on
the left; "Booth
7" on the right
has a rounded
shape.



2



AVOCADO PRODUCTION

INTRODUCTION

Half an avocado and two slices of bread is to many people in the Caribbean a square meal. Although many North Americans consider the avocado an exotic fruit, here in the Virgin Islands it is a popular fresh fruit. It is used to add color, flavor and nutritional appeal to the salads, sandwiches, and many home recipes.

The avocado is rich in fruit oil which is relatively unsaturated so that partial substitution of avocado for saturated fat may have a favorable effect in reducing cholesterol level of the blood. The pulp of the avocado contains one to two percent protein, 10 to 17 percent fat, 1.7 percent total sugar and up to 80 percent water. It also contains moderate levels of iron and vitamins A, B, C, D, E, and K. The meals men-

tioned above, therefore, are more nutritious than they first appear.

There are many soil-related and climatic factors in the Virgin Islands which make growing avocados a somewhat risky business. The yearly occurrence of strong winds, unevenly distributed rainfall, rocky shallow calcareous soils, and scarcity of good quality irrigation water are some of these factors. However, avocados are always in demand in the Virgin Islands and command a ready sale. Local production comprises a small fraction of the total supply, most of which is imported from neighboring islands, and from as far away as Florida.

ORIGIN

The avocado originated in Guatemala and Mexico, but it is now grown throughout the subtropical and tropical world, including the Virgin Islands. The word avocado comes from the Aztec word "Ahuacatl." The Spanish "abogado," and the French "avocat," and

English avocado are all apparently attempts to phonetically reproduce the Aztec name. The "Alligator Pear" name originated because the skin texture of some varieties was equated with that of the alligator.

DESCRIPTION

The Avocado (*Persea americana* Mill.) belongs to the family Lauraceae of which other well known members include cinnamon, camphor, and the bay tree. Seedling avocados grow to a height of 50-60 feet, although budded trees are considerably shorter. Mature tree canopy ranges from small and symmetrical to tall,

upright and asymmetrical (Figure 1). Leaves are simple, elliptical to oblong shaped, and flowers are small greenish-yellow produced abundantly in loose axillary racemes. The fruit is a berry, pyriform to round or oval in shape, and has a single seed with thick fleshy pulp (Figure 2).

CULTIVARS

The avocado has been divided into three horticultural groups or 'races': The West Indian, Guatemalan, and Mexican. These (races) include hundreds of avocado cultivars and classification is based on several factors including fruit size, shape and quality, season of maturity, and altitude at which plants grow best.

The West Indian race is best adapted to lowland tropical conditions—from sea level to 2,500 feet. It is more tolerant of high temperature and humidity, soil salinity, high soil pH, and diseases such as anthracnose, cercospora leaf

spot, and scab, than the other two races.

Tree and fruit characteristics of the West Indian race are similar to those of the Guatemalan, but the fruit is generally lower in oil and ripens 5 to 8 months after blossoming. The foliage is slightly lighter in color than the Guatemalan, and is not anise-scented. Fruits are variable in form and size, the skin is thin—rarely thicker than 1/16"—and soft and pliable.

The Mexican race originated in highland areas, and is well adapted to cool conditions in the tropics and to subtropical areas with a

Mediterranean type climate. It is the most cold-hardy of the races of avocado, but is poorly adapted to conditions of high humidity and temperature, and to fungal diseases which accompany such a climate. It is intolerant of calcareous soils and high soil salinity. The leaves are anise-scented and fruits are smaller than the other two races. The fruits are smooth and thin-skinned and ripen 6 to 8 months after blossoming. The flavor of its fruits may be good, but their small size and large seed make them undesirable for market.

The Guatemalan race of avocado is intermediate between the West Indian and the Mexican races in adaptation to soil and climate conditions. The foliage is darker green in color than the West Indian race, and when crushed is not anise-scented as in the Mexican. The fruit skin is woody and thick (1/16" to 1/8"). In some cultivated cultivars the skin is scarcely thicker than the West Indian race, but is rarely soft and pliable. The seed is comparatively smooth and the seed coat is thin and adheres closely to the seed. The seed is rarely loose in its cavity within the fruit. The fruit ripens 9 to 12 months after blossoming.

The races of avocado hybridize freely, and

many of the leading commercial cultivars are hybrids between members of these races. In general, the West Indian and Guatemalan races and crosses between them are more adapted to lowland and middle elevation tropical conditions. Pollock, for example, a large early fruiting cultivar, belongs to the West Indian race and is a popular cultivar in the Caribbean.

Introduction and selection of avocado cultivars were done by the USDA in St. Croix during the 1950's. Their objectives were to select better quality cultivars, extend the harvest season, and to encourage more commercial plantings. Similar studies on the surviving cultivars of the original orchard are now being carried out by the College of the Virgin Islands Agricultural Experiment Station.

Table 1 lists characteristics of some of the recommended cultivars for the Virgin Islands. In the Virgin Islands, as in all other Caribbean islands, there are also many avocados grown from seedling trees with excellent fruit characteristics. Therefore, there is a continuing need to select and propagate some of these superior local types.

SOILS AND CLIMATE

Although the avocado grows on a wide range of soils, it does best on deep, well drained fertile soils of medium texture, with a pH range of 5.5 to 6.5. It prefers a relatively dry climate with an annual rainfall of 50 inches. However, it will thrive under wide rainfall conditions, provided that the distribution is even and the soil is well drained. The plant does not tolerate severe dry seasons, therefore irrigation is necessary under such conditions. It will not thrive on soils with poor drainage or heavy clays, and is short-lived where the water table is less than 3 feet. Rock layers within 3 feet of

the soil surface also impede the growth of the avocado tree and limestone deposits reduce growth and induce leaf chlorosis. Since many of the soils in St. Croix are shallow with an underlying layer of limestone, special care should be taken in choosing a planting site for avocado. Also with the high pH of some local soils, most trees should be treated with chelated minor elements for best growth and performance (see Fertilizers). In St. Croix new plantings should preferably be located on light soils or rocky slopes where drainage is likely to be adequate.

PROPAGATION

Avocado varieties do not come true from seed and must be propagated vegetatively. Budding, wedge, and side-veneer grafting are methods used to propagate selected avocado cultivars (see Gardeners Factsheets 14, 15). However,

propagating one's own avocado tree does require some skill and experience.

In budding, a small amount of scion material is used, the chances of the scion drying out are less, and the operation is relatively simple. The

TABLE I.
Characteristics of Some Recommended Avocado Cultivars for the Virgin Islands

CULTIVAR	RACE ¹	SEASON OF MATURITY	FLOWER TYPE	FRUIT SIZE (ozs)	PRODUCTION ²	RECOMMENDED USE ³	TREE HABIT	FRUIT CHARACTERISTICS
Pollock	WI	July-Sept.	B	18-40	M	H	Small Spreading	Oblong-pyriform shape, thin smooth medium green skin, thick dark yellow flesh of good quality. Large loose seed.
Simmonds	WI	July-Sept.	A	16-34	M	C,H	Medium to large, spreading	Pyriform shape, slightly flattened on one side, very thin skin, medium green, thick medium yellow flesh of good quality, medium-sized seed tight in cavity.
Melendez-2	GxWI	Nov.-Jan.	B	16-24	H	H,C	Large spreading	Oblong shape with a neck; seed large.
Semil 43	GxWI	Nov.-Jan.	B	20-30	H	H,C	Large spreading	Elliptic (Egg shape); medium sized seed.
Semil 34	GxWI	Nov.-Feb.	A	20-35	H	H,C	Large spreading	Pyriform shape; relatively thick pale-yellow flesh with excellent quality. Small seed, tight in the seed cavity.
Choquette	GxWI	Nov.-Feb.	A	24-40	M	H,C	Large spreading	Oval shape; buttery yellow flesh of excellent quality. Medium-sized seed, fairly tight in seed cavity.
Utado		Nov.-Mar.	A	16-26	H	H	Medium-sized spreading	Pear to ovoid shaped, green brittle woody skin, fairly thick light yellow flesh of very good quality. Medium-sized seed in tight cavity.
Booth 8	GxWI	Nov.-Mar.	B	9-28	H	C,H	Large, spreading	Rounded obovate, thick woody green skin, thick flesh of fair quality, medium-sized seed in tight cavity.
Booth 7	GxWI	Dec.-Mar.	B	10-20	H	C,H	Large, spreading	Rounded obovate shape, thick medium green skin, thick light yellow flesh of fairly good quality, medium large seed tight in cavity.
Lula	GxM	Dec.-Mar.	A	14-24	H	C	Tall, upright	Pyriform, sometimes with neck, smooth light green skin.
Hall	GxWI	Dec.-Mar.	B	20-30	H	C,H	Medium-sized, spreading	Pear shaped with distinct neck, thin leathery green skin peels easily, thick medium yellow flesh of very good quality, medium-sized seed in tight cavity.
Taylor	GxWI	Jan.-Mar.	A	12-18	L	H	Tall, upright	Pear shaped, green brittle woody skin, thin light yellow flesh of very good quality, large seed tight in cavity.

1. WI: West Indian, G: Guatemalan, M: Mexican
2. L: Light, M: Moderate, H: Heavy
3. H: Home, C: Commercial

inverted 'T' is used for budding, which should be done as soon as the seedling stock plant is 8 to 12 inches high.

Best results have been obtained in the Virgin Islands with the wedge graft (Figure 3) using stock seedlings 2-4 weeks after germination. Freshly cut scions from terminal growth containing plump buds and of the same diameter as the seedlings being grafted are preferred. The top of the rootstock is cut off and discarded 3-5 inches above soil level, and the stock is then split 1½-2 inches. The scion is trimmed into a 2-sided wedge with long tapering cuts about equal in length to wedge in the rootstock. The scion is then placed into the wedge in the stock and the graft is wrapped securely, leaving the terminal exposed. With the use of these young succulent seedlings, better than 90 percent success can be obtained. Side-veneer grafting can be performed with older seedlings.

Cut surfaces of the avocado plant are very susceptible to infection, thus budding and

grafting operations should be carried out under very aseptic (sterile) conditions. The scion material should be well protected to prevent drying out. Since the West Indian cultivars are more tolerant of high pH soils, vigorous large seeded seedlings of this race are recommended for use as stock plant for propagation in areas such as the Virgin Islands. The seed from a fresh avocado will germinate within a few weeks. Germination may be enhanced by removing the seed coat or by cutting off the top half inch of the pointed end of the seed. The seed is planted pointed end up to about half its depth.

Established avocado trees of almost any size can be top-worked, or grafted to change cultivars. If the tree is vigorous and healthy, it may be cut off just above ground level, the wound painted, and a side-veneer or wedge graft inserted in a new sprout that will grow out. Follow-up care is important; scions should be shaded and tied to prevent wind damage.

PLANTING

Like any other tree crop, avocados occupy the ground for a long time so that every effort should be made to lay out and prepare the fields properly before planting large areas. The land should be ploughed and harrowed before laying out cambered beds or tree rows. If possible, organic matter dressings should be turned in while the soil is being prepared. In high rainfall areas cambered beds and drains must be made to remove surplus water. On sloping land, contour drains should be put in.

The recommended spacing for grafted avocados is 25 to 30 feet (70 to 48 trees/acre, respectively) apart, depending on expected size of the mature tree. Trees planted too close eventually crowd each other, resulting not only in lower yields, but also in more expensive harvesting since most fruit is produced in the upper half of trees.

The planting hole should be as deep as the root ball and about 6 to 8 inches wider. Well-rotted manure or top soil should be mixed with the soil at each planting site. The young plant is placed in the ground so that the top of the root ball is level with the soil surface, and the sides backfilled with top soil and firmly tapped. A big mound is not needed for planting, but the soil level should be slightly raised to ensure that water does not collect around the plant. Care should always be taken to ensure that the graft-union is well above the soil line. Water immediately after planting to provide adequate moisture to the roots and to eliminate air pockets. During the rainy season especially, it is very important to keep water from accumulating around the young plant, since this may induce root rot (see Diseases).

WEED CONTROL AND CULTIVATION

Avocado trees are shallow-rooted and in areas of limited soil depth weed control is important particularly during the dry months of the year. Cultivation by disking may be harmful since many roots near the soil surface may be damaged. Frequent mowing or cutlassing is

perhaps the best means of weed control. The use of herbicides should be avoided around trees in their first year's growth.

The most economical method for weed control in the first three to four years in an avocado grove is by intercropping, provided

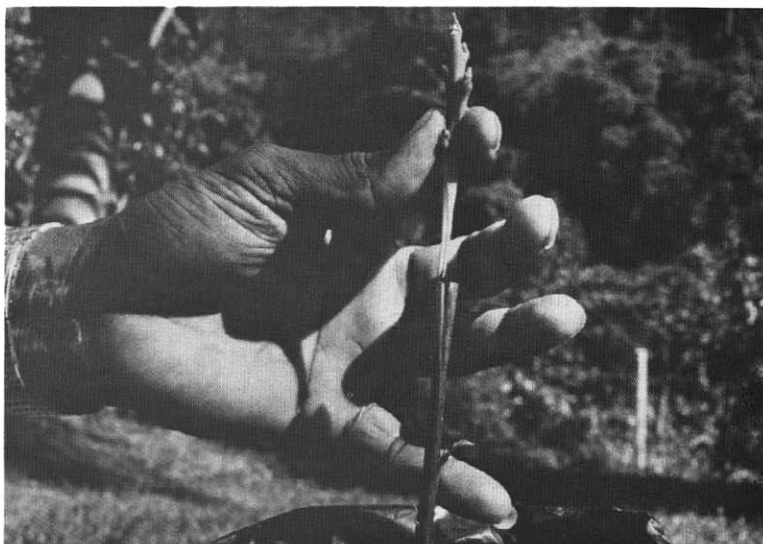
FIGURE 3.



a



b



d



e



c

Wedge Grafting Avocado:
(a) Grafting material
(b) Prepared scion
(c) Prepared stock
(d) Insertion of scion
into stock
(e) Wrapping graft

that the intercrops are not allowed to crowd the young plants. In older orchards where the trees shade the ground, weeds are reduced considerably and very little mowing may be necessary. Chemical weed control with contact herbicides such as weed oil or Paraquat may

be more feasible and economical in this situation, particularly where mowing is prohibited by steep terrain. These chemicals must be used with extreme caution, as with all other agricultural chemicals.

IRRIGATION

Avocado trees require more frequent irrigation than many other fruit trees. Young trees, particularly newly planted ones, need moist soil for vigorous growth. However, the soil should not be allowed to become too wet or saturated. Maintaining adequate soil moisture around older trees helps prevent excessive fruit fall during hot dry periods. The salt con-

tent of the irrigation water (see Table II) is critical for many fruit trees. Avocados are very sensitive to high salt water and can tolerate no more than 300 ppm of chlorides in the irrigation water. Total salinity does not appear to be as important as accumulation of individual ions such as chloride (Cl^-) and sodium (Na^+).

TABLE II.
Classes of Irrigation Water and Permissible Limits of Constituents

Class of Water	Electrical Conductance EC $\times 10^{-3}$ at 25°	Total Dissolved Salts ppm	Sodium Percent of Total Salts	Boron ppm
1. Excellent	Less than 25	175	20	.33
2. Good	25-75	175-525	20-40	.33 - .67
3. Permissible	75-200	525-1400	40-60	.67 - 1.00
4. Doubtful	200-300	1400-2100	60-80	1.00 - 1.25
5. Unsuitable	More than 300	2100	80	1.25

Source: L/V. Wilcox, 1948. *The Quality of Water for Irrigation Use*. USDA Tech. Bull. 962:p.27.

PRUNING AND TRAINING

For most avocado cultivars, very little pruning is required in the first few years of the young plant. However, for upright growing types such as Booth 7 and Taylor, early training is required. Terminal shoots should be pinched after each flush to promote lateral growth. Such pinching is necessary beginning the second growing season and continues until the tree is properly shaped. This helps give the tree a better, stronger spread. Tree height is therefore restricted without loss of growth and production, and the fruit bearing area maintained within reach. If upright growing avocado trees are not trained early, they tend to grow too high. After 6 to 8 years, most fruits are produced in the tree's upper half, making picking difficult and expensive. Successful top-

ping to reduce height after 6-8 years is not possible without greatly reducing future yields and increasing limb breakage.

In the spreading types of avocados, it is desirable to cut back the top of the tree occasionally after several years of production. This also makes spraying and harvesting simpler and lessens storm damage. Such pruning should be done as soon as possible after harvesting. For low bearing trees, it is not necessary to prune low branches to prevent fruits from touching the ground, although propping of heavy fruiting branches may be needed to avoid breakage.

Avocados are particularly susceptible to infection. Pruning, and all other cuts, should be treated with a protective-type pruning paint.

FERTILIZERS

Generally the major element composition of fertilizers used on avocado should not be higher than 10% (see Gardeners Factsheet #16). This is a safeguard against 'salt burning' since avocados, except when planted in ditched-groves, have the great majority of their roots in the top eight inches of soil. This is particularly applicable in some areas of St. Croix where the top soil is shallow with an underlying caliche layer. Young trees are easily injured by excessive fertilizer applications and leaf burn or defoliation and dieback may result.

Nitrogen and potassium are of major significance in avocado nutrition, but nitrogen is more likely to become deficient than potassium in areas where supplemental fertilization is not used. Phosphorus is essential for young vigorous plants, but its relative importance declines as the tree growth rate slows down. Phosphorus in calcareous soils tends to accumulate, becoming available to the plant very slowly but apparently in adequate amounts. Therefore, the amount of phosphorus needed for avocado trees in production is relatively small.

A general fertilizer recommendation would be $\frac{1}{4}$ lb of 10-10-10 applied three times per year during the first year's growth. This should be increased gradually to 1 lb per tree in subsequent years. Extreme care must be taken in areas where shallow rooting occurs and to apply fertilizer evenly to about a foot beyond the dripline area of the tree. For bearing trees, fertilizers containing reduced phosphorus such as 10-4-10 are more suitable. Maximum application should be 4 to 5 lbs per tree per year in 2 or 3 split applications. Chloride-containing fertilizers such as Potassium Chloride are considered unsuitable for avocados. Sulphate fertilizers, such as Ammonium, Potassium and Iron Sulphate should be used as they help in reducing the pH of the soil. It is highly ad-

visable that soil and/or tissue analysis be taken before exact fertilizer recommendations can be made (see Gardeners Factsheet #25).

Among the micro-nutrients, zinc and iron are critical since the avocado is very susceptible to their deficiency. The ideal soil pH for avocado trees is 5.5 to 6.5. Trees growing in soils with pH level exceeding 7.0, as occurs in many areas of the Virgin Islands, will become deficient in minor elements such as iron, zinc and manganese (see Factsheet #16). In such areas, it is therefore advisable to apply the chelates of iron (preferably Fe 138), zinc, and manganese at the recommended rates even before deficiency symptoms appear. Slow-to-start plants may also respond well to foliar sprays of these micro-elements.

Excess of salts such as chlorides and sodium usually occurs in dry areas where there is insufficient rainfall for leaching and where the irrigation water may also contain considerable amounts of salts. The reason that avocados cannot tolerate more than 300 ppm of chloride and sodium is that the plants tend to absorb and accumulate these salts. Damage symptoms are tip and marginal burns of older leaves, ultimately causing defoliation. (This must not be confused with early stages of root rot which exhibit quite similar symptoms). Sodium toxicity symptoms are interveinal leaf burn compounded with twig dieback in extreme situations. Extreme care must be taken when watering avocado plants with potable or well water in the Virgin Islands.

Recent work in other dry areas has indicated that of the three races, the West Indian avocados are more tolerant to the toxicity of salts and to iron chlorosis. Consequently, stock seedlings of West Indian cultivars should be used in the Virgin Islands and other similar areas where the above soil and water problems occur.

POLLINATION

The number of fruits which set and mature is small relative to the number of flowers produced by an avocado tree. Cultivars also differ in productivity and in regularity of bearing, some producing a large crop only every other year.

The avocado flower is bisexual, having both male and female organs. However, the flower performs in such a way that self-pollination is highly unlikely within a given tree or even a given cultivar. This is because each flower opens twice and is closed in between; the first

time it functions as a female, the second time as a male (Figure 4).

Nearly all avocado cultivars (and seedlings) fall clearly into 1 of 2 contrasted categories conventionally designated A and B. A-type cultivars have their first or female opening in the morning. The second or male opening is the afternoon of the following day; the lapse is about 34 hours. B-type cultivars first open in the afternoon. The second opening is the following morning; the lapse is about 24 hours. Therefore, every morning A-pistils can be fertilized by B-pollen, while during afternoons B-pistils are ready to receive A-pollen. For good production in large stands of avocados, con-

sideration should therefore be given not only to planting early, mid-season, and late maturing cultivars, but also to the inclusion of cultivars of different flower types that bloom during the same season.

Wind alone cannot be relied upon to transport pollen because avocado pollen is relatively heavy and drops to the ground. Several conclusive studies have shown the need for the presence of relatively large insects to obtain regular fruit set. The honey bee is probably the chief pollinator but wasps and flies may play an important role. It is very important, therefore, to reduce spraying when pollinators are active.

DISEASES

Avocado Root Rot - (*Phytophthora cinnamomi*)

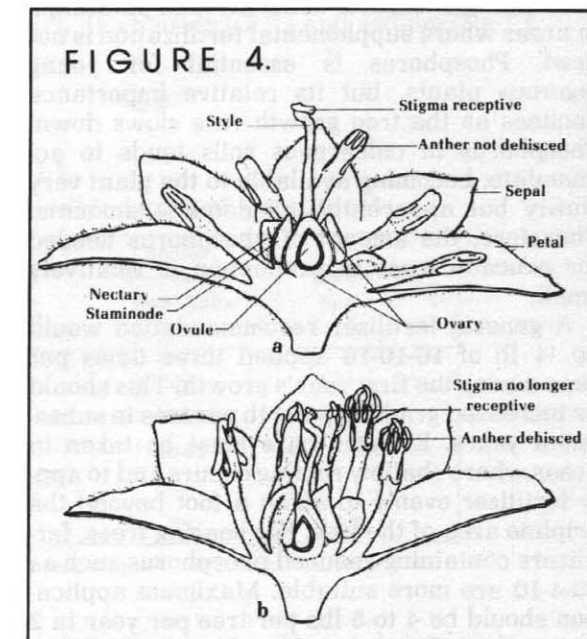
Avocado root rot is a serious fungus disease of avocado in areas with poorly drained soils or a high water table. Leaves become pale green, wilted and branches may die back. A new systemic fungicide still being tested experimentally seems to control this disease by killing the organism on the tree. This treatment is mainly for non-fruiting trees. For bearing trees, fruits must be discarded within 12 months after treatment. The best preventive measure is to plant in well-drained sites.

Anthrachnose - (*Colletotrichum gloeosporoides* Penz.)

Anthrachnose is commonly found on maturing avocado fruit and is the most frequently observed rot of avocados in the market. The first sign of the disease is small light brown to black nearly circular discolorations on the skin of the fruit. As the fruit matures the spots enlarge and the fungus enters the flesh of the fruit causing decay. Anthrachnose can be controlled by sprays of benomyl or copper fungicides.

Avocado Scab - (*Sphaceloma perseae* Jenk.)

The disease occurs on leaves as purplish to dark brown spots visible on both sides of the leaf. The centers of the spots may fall out, leaving small irregular holes. On the fruits, spots are raised, dark brown to purplish-brown and corky. Scab disease is confined to the outer fruit surface and the flesh is not affected. However, the disease reduces the marketability of fruits and scab-infected fruits are also more suscep-



Schematic longitudinal section of avocado flower. (a) Female stage, with stigma receptive, but stamens bent outward and anthers not dehisced. (b) Male stage, with stigma no longer receptive, but stamens upright and anthers dehisced. (Reproduced from McGregor, S.E. 1976. Insect pollination of cultivated crop plants. U.S.D.A. Agr. Hdbk. 496. p.95).

ble to anthrachnose which can increase preharvest fruit drop. Cultivars vary in susceptibility to scab. Generally, the West Indian x Guatemalan hybrids such as Booth 7 and 8 are moderately susceptible, and the West Indian cultivars such as Pollock and Simmonds are least susceptible. Scab is controlled with monthly sprays of finely divided copper or Benlate. A sticker solution should be added to the spray for more effective coverage.

INSECTS AND MITES

Many insect pests attack avocados but they do not limit fruit production significantly. Insect infestations are not predictable and control measures are justified only when large populations build up. The most important pests of avocado in the Virgin Islands are mites, scales, stem borers, and thrips. The avocado rust mite and scale insects can sometimes build up to large proportions. Keeping trees in good healthy condition can very often be sufficient to offset these pests. For young trees sulphur or Malathion can be used to control mites, and Malathion or Diazinon with or without oil for scales and thrips. Care must be taken to see that oil sprays are not used with sulphur or applied to trees that have recently been treated with sulphur. Termites can often attack dead-

wood in trees and may penetrate to the heartwood. They should be controlled at an early stage by spray application of Diazinon into the nest after it is chopped open. The adult weevil of the sugar cane root stalk borer (*Diaprepes abbreviatus*) is sometimes found feeding on leaves and roots. The grub may feed on the roots, especially in potted seedlings. Sevin can be used to control the weevil adults, and Diazinon the grubs, but attacks are seldom of sufficient severity to warrant control measures and Sevin is extremely toxic to pollinating bees. Further information on diseases and pests and their control measures can be obtained from the Cooperative Extension Service Pest and Pesticide Management Program.

HARVESTING

Avocados do not ripen on the tree and fruits picked when immature are of inferior quality. Some experience is required to determine when an avocado is sufficiently mature for harvesting. Generally the skin color becomes more yellowish-green and the surface shine becomes dull in appearance. In certain areas of the tropics, fruit maturity is determined by weight and diameter. Recent research at the CVI Agricultural Experiment Station involves detecting the fruit maturity and subsequent harvest dates by employing an ethylene gas detector. This method has been fully developed for temperate fruits such as apples and pears, and similar technology is now being adapted for some tropical fruits including the avocado.

Usually a quick twist will detach mature

fruits and the stem can then be clipped to give a clean cut. Fruits should always be hand picked and never knocked off the tree to the ground. Picking poles with bags attached to their ends or ladders can be used for harvesting fruits out of arm's reach. Of all production practices, harvesting is the single most expensive operation and requires labor of certain ability and experience.

Field containers should be of 40 lb capacity and market containers no more than 25 lb capacity. They should be padded so as to reduce squeezing and bouncing of fruits. Avocado ripen best at about 60° F to 75° F. Cold storage delays ripening and avocados can be cold-stored at no lower than 45° F for a month or two.

YIELD

Avocado yields tend to be irregular from year to year. With proper management, grafted trees should start bearing about the third or fourth year, reaching their maximum potential between 13-15 years, with an average production

of 5-6 bushels (250-300 lbs) per fruit tree each year. At this rate an average annual production of 6.5 and 9.5 tons per acre (48 and 70 trees/acre, respectively) could be anticipated.

ECONOMICS OF AVOCADO PRODUCTION

Like most fruit crop production, avocado carries with it a heavy initial investment in both the establishment and maintenance of the fruit orchard. Profitable returns from avocado production depend to a considerable extent on its annual yield per acre. However, since yields of commercial significance would not be realized in the first four years, intercropping is advisable as a means of securing a cash flow.

The density of trees per acre is a significant factor influencing high yields as well as higher returns per acre during the early years of production (Tables IV and VI). Table III depicts cost set at \$785.04 (48 trees/acre). This figure was calculated on the basis of all the necessary

recommended inputs except water. The table further suggests that the highest component of the initial investment is that of the young grafted plants and labor. The yield in Table IV shows an average of 7,200 lbs of avocado per acre. An average wholesale price of 50¢ per lb was used, thus a gross receipt of \$3,600.00 per acre was realized.

During the maintenance of the orchard, significant increases in cost over the five-year period only occurred as a result of increases in fertilizer usage. These increases caused maintenance cost to rise in the second, third and fourth year of production.

CASH RETURNS FROM PRODUCTION

Variable cost in Table IV (the cost which occurs with the onset of production) tends to be quite low (\$474.63) when compared with income generated from this expenditure. Returns above variable cost were estimated at \$3,125.37 with the highest cost component being that of labor.

Irrigation was introduced in the year after establishment as a repair expense. However, water requirement was not included due to the fact that annual quantities per tree were not determined.

FIXED COST

In most production operations a fixed cost occurs during the short run as a result of producers' inability to expand their operation during this period. Therefore, some costs are considered fixed irrespective of production.

With respect to fixed cost as stated in Tables IV and VI, equipment was assumed as a basket of items containing shovel, hoe, fork, rake and

hole digger. These items were then depreciated in order to arrive at an annual depreciation cost. The item stated as "other" under fixed cost was calculated as spraying equipment. By subtracting total cost from gross receipt in Table IV, net returns per acre were estimated at \$2,860.54.

RETURNS FROM INCREASED ACREAGE DENSITY

Table V illustrates the density of avocado plants per acre when planted with 70 trees, at a unit cost of \$10.00 per tree. The value of total trees planted was calculated at \$700.00 per acre, compared to \$480.00 in the less densely planted acreage of 48 trees. Another high component cost indicated in Table V was that of labor, which was calculated at \$126.48 per acre. (This did not include pruning.)

The reduction in these components may be possible if plants were to be grafted locally as opposed to importing grafted plants. It may also be possible to reduce labor if mechanical hole diggers are available for rent. Total

establishment cost was set at \$1,083.36 per acre compared to the less densely planted acreage of 48 trees with total establishment cost of \$785.04 as shown in Table III.

Gross receipts as illustrated in Table VI, were calculated at \$5,250.00 from an acreage yield of 10,500 lbs of avocados per annum. Both income above variable cost (\$4,404.61) and net return (\$4,139.80) per acre appear economically attractive. However, with densely populated plants the per acre labor cost will rise as a result of the need for additional pruning, as will the cost of utilizing more mulching materials.

TABLE III.
Estimated Establishment Cost Per Acre
For Avocado Production Using 48 Trees

Items	Input Used	Unit	Cost/Unit(\$)	Value(\$)
Land Clearing	1.00	Acre	20.00	45.00
Plow & Disk Harrow	1.00	Acre	40.00	30.00
Grafted	48.00	Tree	10.00	480.00
Labor	33.00	Hrs.	3.17	104.61
Manure	50.00	Hrs.	—	—
Mulching	48.00	Bale	1.00	48.00
Fertilizer	100.00	Lb.	0.20	20.00
Benlate	1.00	Lb.	12.00	12.00
Malathion	1.50	Gal.	25.00	37.50
Pruning	2.50	Hrs.	3.17	7.93
Total Establishment Cost				\$785.04

TABLE IV.
Estimated Cost and Return Per Acre
For Avocado Production Using 48 Trees

Items	Yield	Unit	Cost/Unit(\$)	Value(\$)
Avocado	7.200	Lb.	0.50	3,600.00
Gross Receipts				3,600.00
Variable Cost	Input Used			
Fertilizer	240.00	Lb.	0.20	48.00
Malathion	0.75	Gal.	25.00	18.75
Benlate	1.75	Lb.	12.00	21.00
Spreader Sticker	0.75	Pt.	2.00	1.50
Mulching	48.00	Bales	1.00	48.00
Pruning	9.60	Hrs.	3.17	30.43
Mowing	1.00	Acre	20.00	20.00
Irrigation Repairs	1.00	Acre	50.00	50.00
Labor	33.12	Hrs.	3.17	104.99
Interest on Op. Capital	3.17	Dol.	10.00	31.70
Subtotal Preharvest				\$ 374.37
Harvest Cost				
Picking & Storing	12.00	Hrs.	3.17	38.04
Marketing Cost	2.00	Trip	31.11	62.22
Subtotal				100.26
Total Variable Cost				\$ 474.63
Income Above Variable Cost				\$3,125.37
Fixed Cost				
Equipment	1.00	Acre	15.00	15.00
Irrigation	1.00	Acre	243.75	243.75
Other	1.00	Acre	6.08	6.08
Total Fixed Cost		Acre		264.83
Total Cost		Acre		739.46
Net Return				\$2,860.54

TABLE V.
Estimated Establishment Cost Per Acre
For Avocado Production Using 70 Trees

Items	Input Used	Unit	Cost/Unit(\$)	Value(\$)
Land Clearing	1.00	Acre	20.00	45.00
Plow & Disk Harrow	1.00	Acre	40.00	30.00
Grafted	70.00	Tree	10.00	700.00
Labor	39.90	Hrs.	3.17	126.48
Manure	105.00	Lb.	—	—
Mulching	70.00	Bale	1.00	70.00
Fertilizer	175.00	Lb.	0.20	35.00
Benlate	1.50	Lb.	12.00	18.00
Malathion	2.00	Gal.	25.00	50.00
Pruning	2.80	Hrs.	3.17	8.88
Total Establishment Cost				\$1,083.36

TABLE VI.
Estimated Cost and Return
Per Acre For Avocado (5-6 Year Old Grafted Tree)

Items	Yield	Unit	Cost/Unit(\$)	Value(\$)
Avocado	10.500	Lb.	0.50	5,250.00
Gross Receipts				5,250.00
Variable Cost	Input Used			
Fertilizer	3.50	Lb.	0.20	70.00
Malathion	1.00	Gal.	25.00	25.00
Benlate	2.00	Lb.	12.00	24.00
Spreader Sticker	1.00	Pt.	2.00	2.00
Mulching	210.00	Bales	1.00	210.00
Pruning	15.00	Hrs.	3.17	47.55
Mowing	1.00	Acre	20.00	20.00
Irrigation Repairs	1.00	Dol.	50.00	50.00
Labor	40.50	Hrs.	3.17	128.39
Interest on Op. Capital	6.25	Dol.	7.00	43.75
Subtotal Preharvest				\$ 620.69
Harvest Cost				
Picking & Storing	12.00	Hrs.	3.17	38.04
Marketing Cost	6.00	Trip	31.11	186.66
Subtotal				224.70
Total Variable Cost				\$ 845.39
Income Above Variable Cost				\$4,404.61
Fixed Cost				
Equipment	1.00	Acre	15.00	15.00
Irrigation	1.00	Acre	243.75	243.75
Other	1.00	Acre	6.08	6.08
Total Fixed Cost		Acre		264.83
Total Cost		Acre		1,110.20
Net Return				\$4,139.80

TABLE VII.
Payback Period from Investment

Year	Maintenance Expense (Using 70 Trees)	Establishment Cost	Year	Maintenance Expense (Using 48 Trees)	Establishment Cost
1		\$1,083.36	1		\$ 785.04
2	\$ 840.50		2	\$ 610.58	
3	829.50		3	601.06	
4	885.50		4	639.20	
5	885.50		5	639.20	
Total			Total		
\$3,444.00 + \$1,083.36 = \$4,527.36			\$2,490.04 + \$ 785.04 = \$3,275.08		
Payback Period = $\frac{\text{Net Cash Investment}}{\text{Estimated annual cash inflows}}$			Payback Period = $\frac{\text{Net Cash Investment}}{\text{Estimated annual cash inflows}}$		
Payback Period = $\frac{\$4,527.36}{\$4,139.80} = 1.09 \text{ years}$			Payback Period = $\frac{\$3,275.08}{\$2,806.54} = 1.14 \text{ years}$		

The economics of increasing the density of plants from 48 trees using an investment of \$3,275.08 to that of 70 trees using an investment of \$4,527.36 demonstrates a marginal profitability of 99¢ for every additional dollar of investment expenditure beyond \$3,275.08 (Table VII).

It is important to state that in the short run the yields from the most densely planted

acreage (70 trees per acre) would certainly be greater than those of the 48 trees per acre, as will revenue from these crops. In the long run (13-15 years) yields from the less densely populated acreage will tend to surpass that of 70 trees per acre. This is due to the fact that the densely planted acreage will have less space for growth and expansion in later years.

MARKETING POSSIBILITIES

The demand for fresh fruits and vegetables in the Virgin Islands is quite stable. Present production levels for most fruits, including avocado, are considerably lower than demand. A recent marketing survey sponsored by the Cooperative

Extension Services suggests that 91.8% of all avocados consumed on the islands are imported. These figures clearly imply a favorable local market demand for avocados.

MARKETING ARRANGEMENTS

Marketing arrangements can be made with several existing marketing channel outlets on all three islands. Currently the bulk of avocado sales are primarily concentrated in the major supermarkets in both St. Croix and St. Thomas. Specialty markets such as local hotels and restaurants are good marketing outlets for local producers. However, special care must be taken to determine the cultivars and seasonal qualities demanded from this market.

Since the heaviest supply of avocados currently occurs between mid-August to Mid-September, producers should look at earlier and later maturing varieties in order to capitalize on higher prices when supplies are low. With the absence of a public marketing board or govern-

ment related agency, all grading, sorting, and packing are usually conducted by wholesalers or retailers.

Local buyers suggest the following guidelines for producers:

(a) Avocados should be fresh and harvested at a mature stage (not when they are ripe). This is done primarily to avoid spoilage and at the same time allow a longer shelf life.

(b) Particular care must be taken to avoid bruising while picking and storing fruit.

(c) If storage is necessary on the farm, temperatures of 65-75 degrees are recommended. On the other hand, if storage capacity and facilities are inadequate then arrangement could be made with wholesalers to transport the

fruits during the time of harvest. Most buyers are willing to provide transportation of fruits from the farm to the place of market should producers have difficulties acquiring transportation. However, when transporting crops to place of market, producers must take care to avoid direct sunlight on the fruit. Air must be allowed to circulate in the container while traveling to destination point, and sprinkling of fruits before travel may also be helpful.

Shipment between islands should be sent on refrigerated vessels to avoid spoilage. Apart from the above arrangement, buyers tend to search for a constant supply of avocados in order to satisfy consumer demand. Some buyers further suggest a farming contract ar-

angement as a means of securing a constant supply. It is therefore important that quantities be determined not only on an annual basis but moreover in terms of quantities available on a monthly as well as a weekly basis. This information will provide buyers with adequate time to contact other producers before supplies end.

Retailing of avocados may be economically attractive to some producers, due to high retail prices. It must be noted that the risks associated with retail selling are also pronounced. That is to say, the costs of storage, packing, grading, sizing and other marketing facilities rest squarely on the shoulders of the producers. Hence, good economic planning should precede all investment.

SOME AVOCADO RECIPES

In selecting avocados, hold the fruit and press gently. If the avocado "gives" a little, it is soft enough for same-day serving. For serving two or three days later, choose firm fruit and keep in a relatively cool place. To ripen the fruit quickly, place in a brown paper bag and check for ripeness each day.

Avocados are versatile food, teaming up well with many combinations. Salads are a favorite way of using avocados and the rich flavor goes well with vinegar and other seasonings. Because of the high fat content, the avocado

combines best with acid fruits and vegetables such as pineapple, orange, grapefruit and tomato. Chicken and seafood are good combined with avocado cubes or slices or used as filling in half an avocado.

The avocado contains a tannin which causes it to become very bitter when cooked; consequently, no successful method of canning has been found. While whole or sliced avocados do not freeze well, avocados may be frozen in a puree form to be used later in molded salads, sandwich fillings, ices and dips.

Avocado Sandwich Fill

Mash scooped-out meat of medium-size avocado. Season with salt and lime juice. Add celery, chives, chopped green pepper, or crumbled crisp bacon if desired. Spread on bread that has been lightly buttered. Whole wheat or other dark breads are very good with this filling.

Avocado Appetizer

Mash avocado, add cream-thinned Philadelphia cheese, minced onion or chives. Heap into pieces of celery.

Deviled Dip

Scoop meat from 1/2 large ripe avocado, leaving shell intact. Mash avocado meat, blend in 1 family-size can deviled ham, 13-ounce cake

cream cheese, minced parsley and seasoning to taste. Mix smooth and pile in reserved shell. Serve surrounded with crisp fresh vegetable pieces, potato chips, small crackers.

Barbecue Spread

Delicious on hamburger slices or hot meat loaf. Stir in 1 cup sieved or mashed avocado, 3 tablespoons mayonnaise, 2 tablespoons tomato catsup, 1 tablespoon lime juice, and salt, tabasco sauce, chopped green chili peppers and onion to taste.

Avocado Medley Salad (serves 6)

2 medium avocados diced
2 medium tomatoes diced
1 tablespoon minced onion
2 tablespoons diced celery (continued)

(continued)

¼ cup diced cucumber
1 tablespoon diced green pepper
¼ cup mayonnaise Lettuce
Peel and dice all vegetables. Dice avocado last and toss all together lightly. Add mayonnaise and toss to coat. Pile in lettuce cups and chill until serving time.

Frozen Avocado Puree (serves 6)

4 ripe avocados of medium size
½ cup lime juice
Halve avocados, remove peel or with a spoon scoop pulp from shell into a bowl. Sprinkle with the lime juice. Mash or blend until smooth. Pack into glass jars leaving 1 inch head space. Seal airtight and freeze at 0°F.

To use, remove from freezer and allow to thaw in refrigerator in container. This will take about 24 hours. Keep tightly covered until used.

Cream of Avocado Soup (serves 6)

3 avocados (or 2½ cups frozen puree)
2 cups chicken broth
1 cup heavy cream Whipped cream
Salt White pepper
Mash two avocados with silver fork and press through a fine sieve or puree in a blender. Place in top of a double boiler. Add chicken broth which has been lightly seasoned. Heat, stirring occasionally, until soup comes to a boil. Stir in heavy cream. Cover, keep hot over boiling water. When ready to serve stir in the remaining avocado cut in ½-inch cubes. Season to taste with salt and white pepper. Serve with a tablespoon of lightly salted whipped cream on each serving.

Avocado Fruit Salad (serves 6)

1 avocado ½ cup coconut,
½ cup halved seeded shredded and
 grapes toasted
2 cups grapefruit Lettuce
 section French dressing,
red or green cherries minted
Cut avocados in half but do not peel. Scoop out halves with French ball cutter or teaspoon. Combine with grapes and grapefruit. Marinate in French dressing which has been seasoned with chopped mint leaves. Pile into scooped out shells. Arrange on lettuce. Serve individual servings from shells, or arrange fruits on beds of lettuce in individual servings. Sprinkle with toasted coconut. Garnish with cherries.

Seafood Avocado Salad (serves 6)

1 cup cooked lobster meat
2 cups cooked crabmeat
2 cups cooked shrimp (or your own favorite seafood combination)
3 avocados 1 tablespoon cut
½ cup mayonnaise chives
½ cup sour cream French dressing
Remove any bits of shell from lobster and crabmeat. Break into bite-size pieces. Remove a few chunks of lobster and a few whole shrimp for garnish. Cut remaining shrimp into pieces. Combine lobster, crabmeat and shrimp. Add just enough French dressing to coat generously. Chill. Just before serving, cut avocados in halves, remove pit and fill with seafood mixture. Combine mayonnaise, sour cream and chives for dressing. Top each avocado with a generous spoonful. Garnish with whole shrimp and lobster chunks.

Baked Stuffed Avocado (serves 6)

3 avocados Dash of pepper
¼ cup lime juice Dash of cayenne
1 cup flaked 1 teaspoon minced
 crabmeat onion
1 cup cream sauce 1 cup grated cheese
Dash of salt
Cut avocados in halves lengthwise. Remove pits. Sprinkle avocado with lime juice and salt. Combine crabmeat and cream sauce. Season to taste with salt, pepper, a pinch of cayenne and onion. Fill avocados with mixture. Sprinkle with grated cheese. Arrange avocados in baking pan with half an inch of water in the bottom. Bake in a moderate (350°F) oven 15 minutes or until cheese melts and avocado is heated through.

Guacamole

Make thin paste of 1 cup mashed avocado, 1 small finely chopped onion, 1 clove finely chopped garlic, a dash of Worcestershire sauce, ½ teaspoon olive oil, a dash of paprika, and a little lime juice, salt and pepper to taste. Blend to a smooth consistency in electric blender and serve on crisp crackers or with potato chips, as a dip.

Avocado Refresher

Heap balled or diced avocado in sherbet glasses and chill. Season with salt lightly and cover with Thousand Island dressing or with tomato catsup seasoned with lime juice, salt and pepper.

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