AVOCADO CULTURE.*

(FARMERS' CIRCULAR 1.)

By F. G. Galang, of the Horticulture Section, Bureau of Plant Industry, Manila.

In its native home, tropical and semi-tropical North and South America, the avocado (*Persea americana* Mil. and P. *drymifolia* Ch. and Sc.) is an important food of the inhabitants. In the Philippines, however, it is still considered a luxury fruit since the present price is not within the reach of many. Of the many species and varieties of fruit trees introduced into the Philippines, none has gained so wide a reputation within a short time as the avocado. Although it is said to have been brought into the Philippines from Mexico in 1890, yet it was not successfully grown here until 1903 from planting materials received from Hawaii, Costa Rica, and the United States of America. The Bureau of Agriculture (now the Bureau of Plant Industry) began the distribution of avocado in the Philippines in 1913, and with the co-operation of the College of Agriculture of the University of the Philippines, it is able to produce many avocado trees bearing fruits in many provinces. Approximately, 22,000 trees are now found growing in the Philippines, 4,500 of which are already bearing fruits.

Varieties.

Avocado trees vary in habit of growth; some are tall with short lateral branches while others have spreading branches. The leaves are usually medium thick and leathery, and they vary in shape and size. The flowers are borne in compact panicles generally at the end of the twigs. The fruits are variable in shape, size and colour. The surface colour of the fruit, when ripe, varies from light green to dark green, purple, brown, red, crimson, or maroon. The rind may be thin and delicate to thick and leathery and enclosing a large seed. The pulp is very nutritious, rich in fat, appetizing, with nutty flavour, and of a buttery consistency. There are three avocado races, namely, the West Indian, the Guatemalan and the Mexican types. Each of these types requires a different elevation for its development and possesses different characteristics, as follows:—

West Indian.—The fruit of this type has a poor shipping quality, loose-fitting, and with rather large seed. According to Stahl they contain from 4 to 7 per cent. fat. The skin is medium thick and is always smooth and leathery. The seed coats are usually separated, and the cotyledons are rough on the surface. The fruit stems are short. The Philippines grow varieties under this type as the Pollock, Family, Cardinal, Wilson, Waldin, Wester, and Baldwin.

Guatemalan.—This type has a thick woody rind, producing dull, large and rough fruits. The seed is small and invariably tight-fitting; the fruits are of good shipping quality, the meat of which is drier than that of the West Indian. The surface of the cotyledons is smooth. It contains more fat (from 10 to 13 per cent.) but less carbohydrates. The fruit usually is borne on long fruit stem. The young leaves are frequently reddish or bronze in colour instead of green. The Dickinson, Lyon, Tertoh, Taft and Tumin are the varieties of this type already cultivated in the Philippines.

* Reprint from Farmers' Circular No. 1—"Avocado Culture" by F. G. Galang—of the Horticulture Section, Bureau of Plant Industry, Manila.

Mexican (*Persea drymifolia*).—The foliage is anise-scented, small, and sharp at the apex. The fruit is small with thin, smooth rind which generally adheres to the pulp and is of purplish black in colour. It contains a higher percentage of fat (from 12 to 15 per cent.). The seed is large with thin coats which are either separated or adhering to the cotyledons. The surface of the cotyledons is smooth. The varieties under this type that are already grown in the Philippines are Ganter and Puebla. Seeds of the Gottfried and Northrop were successfully introduced in 1924.

In planting avocado, one of the most perplexing problems is the choice of the right varieties, and this is due to a considerable variation in the productiveness of avocado trees. Some trees profitably bear fruits every year; others only in alternate years; others do not bear any fruit at all. Many varieties fail to bear fruits satisfactorily owing to lack of pollination brought about by the failure of the flowers to open at the proper time or to the incompatibility of the pollen itself. Generally, fruit bearing in avocado will be more successful if compatible varieties are interplanted and if their flowers open at such time as will permit cross-pollination, or if self-compatible varieties are planted, the opening periods of flowers overlap. However, the varieties to be interplanted should have approximately the same flowering time—early varieties should not be interplanted with late varieties and vice versa. The mid-season varieties can be interplanted with either the early or late varieties.

Of the hundreds of varieties now planted in the United States of America, not a single one has so far been selected that gives all the desired qualities. Each has some defects. And these varieties will have to be replaced eventually by a more desirable variety, or strain. In the Philippines, numerous seedlings and named varieties have already been imported and planted. Of those that have so far fruited, some are good, while others produce small fruits of poor quality. Moreover, many had failed to maintain themselves under local conditions. Altogether not less than 100 varieties and strains of avocado have already been introduced, out of which about 40 varieties are surviving and seventeen are bearing fruits. However, according to the list of avocado varieties given in the 1929-30 annual report of the California Avocado Association, there are 342 varieties, classified as follows: 62 Mexican, 78 West Indian, 152 Guatemalan and 50 unclassified. In addition, a score or more varieties and strains are fast developing in the United States of America and elsewhere. Therefore, aside from the varieties already found growing in the Philippines there are many more varieties and strains which merit further planting and introduction. Nevertheless, until new varieties, or strains, have proven to be superior and especially adapted to local conditions, the Philippine grown avocado varieties, which have fruited for several years, should be given preference in starting an avocado orchard. Of the many varieties that have been introduced and distributed, only a few have so far gained popularity. The Cardinal, Pollock, Lyon, Wester, Tertoh, Family, Cummins, Commodore, Cyrus, Quality, Douglas, Vega and Miami have fruited successfully in Lamao, Bataan and elsewhere in the islands. But due to the limited extent of their trial, their selection should not be considered final. The Cardinal has predominated, however, probably because of its productive habit under certain soil and climatic conditions.

When selecting the varieties to be planted, one should be guided by the following points: the trees should be hardy, productive, regularly bearing, disease and pest resistant, early or late bearing; the fruit should be of good flavour, quality and size; and the seed should be comparatively small. It should be borne in mind that the fat content does not indicate a good quality, for in the United States of America the most prized varieties are poor in this respect.

Requirements.

The avocado is distinctly tropical and subtropical in its requirements. There are now avocado trees growing in widely separated localities in the Philippines, and the behaviour of these trees clearly indicates that the plant is at home in this country. In localities where the dry season is not too long, they thrive with very little attention. However, when the dry season extends for four or five months, they require some irrigation unless the soil moisture is within the reach of the roots during the driest part of the year.

The tree is not exacting in its soil requirements so long as good drainage is afforded. It is very intolerant of standing water, and cannot endure it for any length of time. Deeply and well-drained soil, which is rich in organic matter, is the best for avocado, but well-drained heavy soil of average fertility will also grow good avocado, especially in moist regions. Any soil where citrus trees thrive will produce good avocado trees.

Like most other fruit trees, the avocado does not thrive well in places exposed to strong winds. Its leaves cannot quite resist excessively hot, dry winds. Besides, winds increase the evaporation of water which in turn may cause a heavy dropping off of immature fruits. Also the fruits are liable to suffer injury through rubbing against the branches or against each other, and the danger of the breakage of limbs, especially those heavily loaded with fruits, is increased. However, this is not a limiting factor in avocado culture, because it can be remedied by planting windbreaks in places where there is no natural protection from the winds. Windbreaks reduce the air movement and so diminish evaporation. Windbreaks should be planted around the orchard; if the plantation is large, windbreaks should be planted in every hectare lot.

The West Indian varieties are very tender, and are best adapted to low and medium elevations up to 900 metres above sea level. The Guatemalan varieties are rather intermediate, and have wider range of adaptability. They can be grown from sea level up to an elevation of 2,500 metres, but an elevation of not more than 700 metres is the best. The Mexican varieties are the hardiest with respect to cold weather, and have a wide distribution. They thrive best from 600 metres upwards.

Propagation.

The avocado is propagated by seeds, by budding, grafting, inarching, or marcotting, but preferably by budding or grafting. Inarching and marcotting are too laborious and expensive. Grafting sometimes gives a better result than budding. The grafted plants are oftentimes more vigorous than the budded ones. On the other hand, trees grown from seeds usually do not come true to type. The chances of obtaining a fruit of better quality than that produced by the parent tree are very slim. It is the experience of avocado growers that seeds are unreliable means

of reproducing a variety. However, if seeds have to be depended upon for the propagation of avocado, the seed of some avocado varieties may be carefully halved so as to produce two plants from each seed. The resulting plants, however, should be given a reasonable dose of fertilizer in order to produce good growth. Generally, the whole seed germinates earlier, and the resulting seedlings are more stocky and have more number of leaves than the halved seed.

The first step in the production of budded or grafted trees is the raising of the stock plants. In the United States of America the varieties of the Mexican type are commonly used as stock plants because of their greater hardiness against frost than the large-seeded and hard-shelled varieties in spite of the greater amount of plant food in the seed of the latter. But this type possesses a wide range of variability, and caution should, therefore, be taken in using it as a stock plant in the Philippines. On the other hand, the West Indian seedlings, being generally more vigorous than the other types, may prove good stock plants at lower altitudes in the Philippines, although they were proven less successful as scion for the Mexican stock. The Guatemalan type will succeed both the West Indian and the Mexican stocks. This type is vigorous and thrifty, but somewhat tender, although less so than the West Indian. Fuerte, a hybrid between Guatemalan and Mexican types, is much used as stock plant in the United States of America nowadays.

As the seed of the avocado loses its vitality quickly, it should be planted while it is still fresh. And if the seeds cannot be planted at once, they should be stored in properly moistened sand, sawdust, charcoal, or sphagnum moss. The seeds may be planted directly in bamboo pots or in seed beds with the pointed end up. About one-fourth of the seed should be left exposed so that the resulting sprouts can be thinned out, leaving the strongest one. Set the seeds 40 or 50 cm. apart in the seed beds. In potting, the soil should contain one-third each of sand, loam, and well-rotted compost. If sown in seed beds, the soil need not be so rich—a sandy loam soil being sufficient. It is sometimes advisable to grow the seedlings for budding or grafting in the seed beds although it will require more labour to remove them properly when transplanting them in the field. Seeds should not be allowed to dry out, otherwise they will lose their viability.

Budding or grafting is done in the same way as in citrus or other fruit trees. It can be done any time the stem of the stock plants has attained the size of a little larger than a lead pencil provided it is not raining and that the seedlings are in condition, that is, the sap is flowing freely. The scion should be selected from the best tree of the desired variety, should be well matured, preferably from twigs which are just ready to send out a new growth, and should contain plump and well-developed buds.

Avocado stem is very brittle so that in forcing the bud to grow, a notch should be made of a few inches above the bud instead of cutting the stem half-way into the wood of the stock for lopping as in the case of other fruit trees. In lopping never bend the stock as in other fruit trees in order to avoid a premature breaking.

When the scion is already well advanced the top of the stock may be cut off entirely about 10 cm. from the bud. After the bud has grown to a length of about 25 cm., the stock should be cut off clean just above the union of the stock and the scion, and the cut surface should immediately be painted with white lead or other suitable materials. This will protect the wood from decay.

Planting.

When the plants are about 50 cm. high or more, they can be transplanted in the field at the beginning of the rainy season, at a distance of about 8 to 10 metres apart in holes large enough to accommodate the plants. Set the plants as deep as they grow in the nursery, and use good surface soil for refilling the holes. The soil should be packed firmly around the plant. It is well to pour in water while firming the soil. If water is available, planting may, of course, be done late in the rainy season, and even during the dry season. In transplanting, great care should be taken so as not to injure the root system, which is very delicate, and the roots should never be exposed to dry, or else the plants will die. To avoid the least injury to the roots, the plant should be dug from the nursery with a ball of earth. In planting balled trees, it is necessary to remove the sack or wrapping materials from around the ball of earth, as the sack will decay in due time. However, to facilitate the rotting and the penetration of water, two or three cuts should be made at the sides with a sharp knife. Split and remove the pot in transplanting the potted plant. Cut one-half of the leaves or young twigs of the plant previous to transplanting. The newly-transplanted plants should be watered and mulched from time to time as may be necessary. In watering, a basin should be made around the tree to hold the water. Shedding the newly-transplanted plant is necessary if planting is made during the dry season. Care should be taken that varieties are planted together, which will provide for each other at the time when each is ready for pollination.

Orchard Management.

A modern fruit orchard should be well cultivated, irrigated, fertilized, cover-cropped, pruned and mulched from time to time. The cultivation of young avocado orchard is done in the same way as in citrus, that is, deep ploughing is advisable at the beginning; but when the trees are already big, deep cultivation should be avoided as much as possible, otherwise there is danger of destroying part of the root system and exposing the soil. At this stage the tree can be kept clean by occasional hoeing of the ground near its trunk. Mulching the trees and planting cover crops between the spaces are beneficial for the upkeep of the trees, since both prevent soil erosion and replenish the nitrogen and organic matter of the soil. Legumes have the power of gathering free nitrogen from the air and storing it in their nodules, and are, therefore, more valuable as cover crops than non-leguminous plants.

In order to get the most profit from the trees, it is always a good practice to maintain the fertility of the soil. To accomplish this, fertilizers should be applied regularly to bearing trees. There is a wide diversity of soil in the Philippines, so that to give advice regarding the kind and amount of fertilizer without knowing the condition of the soil is almost futile. However, the kind of fertilizer needed by avocado is probably not very different from that needed by other fruit trees, although the amount may differ. And in the absence of experimental data no definite and specific information is given. The condition of the tree and of the soil should be determining factor as to the kind and quantity of fertilizer to be used.

A young tree requires very little, if any, commercial fertilizer until it begins to bear fruit heavily. Animal and poultry manure and nitrogenous commercial fertilizers are, however, beneficial to young avocado trees. A complete fertilizer

which is low in nitrogen and high potash is good for fruit-bearing trees. In the United States a mixture containing 5 per cent. nitrogen, 7 per cent. phosphoric acid and 2 per cent. potash, the nitrogen being derived from organic materials, has given good results on young trees when applied at the rate of 1 lb. per tree, three or four weeks after planting, and 8 to 10 lb. on five-year-old trees. The percentage of potash is increased while the trees come into bearing—5–8–3 or 6–6–3 in spring, 4–8–10 in the fall, and 4–7–5 or 5–5–5 in summer.

As a general rule, avocado requires little or no pruning at all after each tree is properly established. However, inasmuch as the avocado plant is naturally weak and brittle, the pruning of forking branches and shortening of young and spindling twigs may be done to strengthen the stock and the framework of the growing trees. This is to be done at their dormant stage. The mere pinching of undesirable shoots may induce the growth of other buds where an extension is needed in order to make the trees more or less symmetrical in growth. Tall-growing trees should be pinched back. Again, some thinning of the branches should be done from time to time so as to permit sunlight to the inside foliage. Of course, any heavy pruning should be avoided, as this will greatly accelerate the vegetative growth and delay the fruiting period. Only dead and undesirable branches should be removed after the fruits have been harvested. All wounds should be painted with white lead or other suitable materials to avoid rotting.

In places where there is a uniform distribution of rainfall, the avocado need not be watered at all, but in places where there is a prolonged dry period watering is necessary unless the ground water is high or is within the reach of the roots. The water may be distributed in the way which is most convenient, economical, and effective. The furrow system of irrigation should be practised on big plantations whenever it is practicable for the sake of economy, and the bucket system may be used for watering the individual trees around the house. Where there is lack of water in the soil, the trees may shed much of their foliage, flowers or fruits.

It is often advisable to top-work undesirable trees in the orchard to a good variety. This can be done by cutting the tops back, including the big branches. Of the numerous sprouts which appear, only a few good ones should be left for budding or grafting with selected scions. The cut surfaces and the trunk should be painted and whitewashed in order to protect them from decay and sunburn.

Pests and Diseases.

There are comparatively few insect pests and diseases which at present affect the avocado in the Philippines. Among the insects, the borers and the scale insects, including mealy bugs, are found destructive to our avocado trees. Other pests are the thrips, caterpillars and white ants.

The borers are found to attack the trunk, pith and twigs. They work their way downward, destroying all growth thereby, and may eventually kill the tree. Limewash may lessen the infestation.

The caterpillars attack the leaves and flowers. They can be controlled by spraying either with lead or calcium arsenate.

The thrips attack the flowers, but they can be prevented by dusting with pyrethrum, derris powder or tobacco dust.

The scale insects suck the sap of twigs, leaves and fruits. Heavy infestation weaken the tree, and sometimes cause premature falling of fruits. Oil emulsions and soap-suds are usually effective in controlling the scales.

The important diseases of avocado are die-back and anthracnose. The anthracnose is a disease of the leaves, bark, and fruit. The affected portions turn black with sunken spots, usually circular in form. It can be controlled by spraying with Bordeaux mixture. The infected parts should be cut and burned.

The die-back is a disease of the twigs. The infected parts become dry. It can be prevented by spraying the trees with lime sulphur or Bordeaux mixture. These sprays should be applied periodically once every two weeks at least, as the new flushes appear until they mature.

Other diseases of minor importance which may also be controlled are the scab and the leaf spots.

Harvesting and Yields.

The avocado season in the Philippines is from January to March and from June to September, depending upon the climate of the locality. In humid districts the season is rather early. There are, therefore, only two short periods in the year during which avocado fruit is not obtainable in the market—from April to May and from October to December. However, by planting varieties which fruit at different times of the year, it is possible to produce avocado fruits all the year round. In the United States the Fuerte variety is said to be fruiting from November to May; Verde from March to May; Puebla from November to December; and Taft from May to November.

Avocado trees grown from seedlings begin to bear fruits when about four to eight years old, six being the average. On the other hand, vegatively-grown trees sometimes begin to bear fruit the first year in the nursery. At this age, however, and probably up to three years, they should not be allowed to fruit at the expense of the future growth and vigour. The annual yield of a full-bearing tree ranges from a few to 500 fruits—sometimes from 800 to 1,200 fruits. An average of 500 fruits a year per tree is considered a fair yield. Generally the yield varies from one season to the next, partly depending upon the size of the previous crop, rainfall, winds, and the condition of the tree at the flowering season.

The avocado fruits are very perishable and should be handled with care. In harvesting, the fruits should be carefully clipped off, leaving a short stem on them for handling purposes. A fruit-picker provided with a knife similar to that one used in picking the mango fruits should be used in harvesting the fruits of tall-growing trees. Furthermore, the avocado should be harvested when fully matured, and not allowed to ripen on the tree. The maturity of the fruit is indicated by its colour. For example, the appearance of reddish streaks in the case of purple-fruiting varieties and the change of colour from green to a lighter green in the case of green varieties are indications of maturity. In the thin-skinned forms the ripeness of the fruit can be determined by external pressure, but in the very thick-skinned varieties this cannot be done. The ripeness of the fruit of the latter vareties can be determined by the stems when it is easily pulled out of the fruit, and when a toothpick can be easily pushed through the stem it indicates that the fruit is ripe enough for eating. If the fruit is picked before

reaching maturity, its flavour is poor, while, if left too long on the tree, the keeping quality is impaired. The fruits should be placed in a basket or box lined with packing materials, such as dried straw, banana leaves, &c., when intended for short distances shipment; when the fruits are to be shipped long distances they should be wrapped individually with soft tissue paper.

Uses.

The avocado fruit is rich in fat and protein, but low in sugar content. Its oil is similar to olive oil, and can be used for the same purposes. It has been known in countries where avocado has been long grown that its fruit is a wholesome and highly-digestible food. Wolfe and others said that an ounce of avocado contains about 73 calories, which is nearly three times that of banana, one and a half times that of beefsteak and other meats, and three times that of several kinds of fish. And, because of this and its low carbohydrate content, it is a good food for diabetic people. Its iron content is about three times that found in other common fruits, and, therefore, it is a good food for anæmic people.

In the Philippines the fruit is eaten with sugar and milk, or in frozen form, or as ice-cream ingredient. Few people eat the meat offhand. In the United States it is extensively used as a salad fruit, because of its delicate, nut-like flavour, and its smooth, buttery consistency. The avocado should not be considered merely as a salad fruit, but as a substantial food which may be used in a great many combinations. For it is also eaten offhand, with the addition of lime or lemon juice, or salt, or sugar only. Mashed and seasoned, the meat is used as sandwich filling or is spread on salted crackers. Often it is also added to soup just before serving. A number of recipes on how to eat avocada fruit have been published from time to time.

REFERENCES.

Barrett, O.W.—*The Tropical Crops.* (The Macmillan Co.), New York 1928.

Condit, I. J.—"Correspondence Courses in Avocado." Lessons I.-III., College of Agric., University of California, Berkeley, U.S.A.

De Leon, Jose, and Felipe, Padolina—"Avocado—a Choice Fruit." Bureau of Plant Industry Cir. No. 212.

Galang, F. G., and Emilio K. Morada.—"Flower Behaviour of Avocada Varieties." *Phillip. Journ. of Agric.*, 6, No. 6 (1935).

Nesom, G. E.—Press Bulletin No. 11, Bureau of Agric. (1907).

Popenoe, Wilson.—*Manual of Tropical and Sub-tropical Fruits* (McMillan).

Stahl, A. L.—"Changes in the Composition of Florida Avocados in Relation to Maturity." Florida Agr. Exp. Sta., Bull. 259 (1933).

"Composition of Florida Avocados." *Proc. Fla. Sta. Hort. Soc.*, pp. 81-86, 158-162, and 193.

St. Clair Fielden, G.—"Vegetative Propagation of Tropical and Sub-tropical Fruits." Imp. Bureau of Fruit Production, Tech. Com. 7, June (1936).

Stout, A. A.—"The Pollination of Avocados." Fla. Agr. Expt. Sta., Bull. 257 (1933).

Wolfe, H. S., Toy, L. R., and Stahl, A. L.—"Avocado Production in Florida." Agr. Expt. Bull. 272, University of Florida (1934).

Annual Reports.—Cal. Avocado Assoc., 1924-36 and 1929-30.