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AVOCADO PRODUCTION IN ASIA AND THE PACIFIC



FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
REGIONAL OFFICE FOR ASIA AND THE PACIFIC
BANGKOK, THAILAND, JULY 2000



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This publication brings together edited manuscripts of papers presented at the Expert Consultation on “Avocado Production Development in Asia and the Pacific”, held in Bangkok, Thailand, 27-29 April, 1999. The Consultation was organized and sponsored by the FAO Regional Office for Asia and the Pacific. The Report of the Consultation was brought out in June 1999 (FAO/RAP Publication: 1999/19).

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FOREWORD

Avocado has been known for many centuries, dating back to at least 1519. It is highly regarded today as an important fruit for food and nutrition. However, this fruit has not yet been popularized in Asia, most likely due to unawareness of its merits and qualities, despite remarkable development in every other continent.

Given the relatively high food and nutrition value of avocados, large scale production and consumption of this fruit could considerably alleviate the malnutrition problem in the developing Asia. There is, therefore, a very good opportunity and potential for the development of a viable avocado industry in Asia. The countries of the region are, therefore, encouraged to give consideration to commercial avocado culture. This called for critical diagnosis of the constraints to avocado production and effective solution of the problems.

Against the above backdrop, FAO organized a Regional Expert Consultation on Avocado Production Development, at the FAO Regional Office for Asia and the Pacific, Bangkok, Thailand, from 27 to 29 April 1999. Experts from concerned countries participated in the workshop. They were able to identify critical issues needing immediate attention. The report of the Consultation was published as FAO/RAP Publication No. 1999/19, in June 1999, highlighting the major recommendations. This publication collates further useful information in the form of Proceedings.

Appreciation is expressed to the participants for the presentation of papers and contribution to the discussions. In particular, sincere thanks must be accorded to Mr. M.K. Papademetriou for compiling and editing this valuable document. Also, the unfailing support of Mrs. Valai Visuthi, who provided assistance in formatting the manuscript, is greatly appreciated.

R.B. Singh
Assistant Director-General
and FAO Regional Representative
for Asia and the Pacific

INTRODUCTORY REMARKS

Minas K. Papademetriou *

Welcome to the FAO Regional Office and to this Expert Consultation. You may wish to know that this Consultation has been organized and sponsored by the FAO Regional Office for Asia and the Pacific. I am grateful to all of you for coming here to contribute to this Meeting.

Avocado is highly regarded today as an important fruit for food and nutrition. Remarkable development of this fruit has been recorded in every continent, with the exception of Asia. Unfortunately, this fruit has not yet been popularized in Asia, most likely due to unawareness of its merits/qualities. However, Popenoe (1935) considered the avocado as 'God's greatest gift to humanity'. Now, more than two generations later, Asians need to listen freshly to the wisdom of this truth. Much real starvation and malnutrition in a number of Asian countries, such as Bangladesh, India and Nepal, could be averted by growing avocados, whose product has a relatively high food and nutrition value.

Avocados are rich in important human nutrients. There has been recently increasing recognition of our need for antioxidants for good health, and the avocado is rich in three of the most important ones, i.e. vitamins E, C and A (beta-carotene). It may help to prevent strokes; it is high in potassium and low in sodium. Among fruits, it is noted for the quantity and quality of its protein. It provides exceptional quantities of both types of dietary fibre. It makes a superior weaning food for babies. The avocado fat consists predominantly of monounsaturated oleic acid, which has been found to reduce harmful LDL-cholesterol while maintaining beneficial HDL-cholesterol, performing better than the usual low-fat diet. In addition, the avocado has various uses as a natural cosmetic, with advantages in rapid skin penetration, and as a superior natural sunscreen.

The population of the region is over 3 billion at present and it is expected to be over 5 billion by the year 2025. This additional 2 billion people must be fed. Who will feed them? And what will they be fed? Moreover, malnutrition is already a serious problem, and it is attributed to an imbalanced diet. The opportunity to build up demand for nutritious foodstuffs seems to beckon. There is an opportunity and potential here for the development of a regional avocado industry, along with its nutritious products. Apart from the local markets, there are opportunities for the export markets of the region. Japan, Korea and Hong Kong are already importing avocados from countries of other continents (Mexico, USA, etc.). Some other countries in the region are also importing avocados, but in small quantities. Imported avocados in Bangkok are selling for US\$2.00 per fruit. In addition, Western European markets still have considerable growth potential. The opinion of many people is that the demand for avocado will continue to grow throughout world markets.

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The opportunities for the development of a viable avocado industry appear to be very good. However, at the same time, the problems to be addressed are serious. With the exception of Australia, New Zealand and Sri Lanka, no other countries in the region have improved varieties available for the farmers. There is, therefore, a need for each country to embark on a strong varietal improvement programme. The problem of propagation/multiplication needs also to be addressed. In addition, farmers need to become familiar with the improved cultural practices to be followed. Post-harvest handling, processing and marketing issues also need to be given due attention. Then the region should be in a position to produce best-quality fruit at low cost.

Inter-country cooperation could be very helpful in achieving the common goal. Strengthening cooperation among countries, institutions and individual scientists in production development is very important. A forum like this allows us to learn from each other. We must explore the possibilities of sharing our experiences for mutual benefit. It is in this context that this Consultation has been convened. Briefly, its objectives are the following:

- a) To review the status of avocado production in Asia and the Pacific, and discuss the problems faced as well as strategies required to overcome existing problems.
- b) Elaborate on the potential and opportunities for avocado production development.
- c) Discuss ways and means of strengthening collaboration on avocado research and development.

Distinguished participants, our Meeting will end in three days. As we will leave it behind us, we should take with us the power to shape the things to come regarding the avocado industry. You possess some power to affect the region's food supply in a significant way. All of you attending this Meeting have some power to consolidate and lead a regional avocado industry. Please pledge yourselves to use that power wisely. The destiny of a regional avocado industry may well be in your hands.

I wish you all productive discussions and good contacts among one another for the exchange of information, experience and expertise.

WELCOME ADDRESS

Prem Nath *

It is a great pleasure and privilege for me to welcome you to the Expert Consultation on Avocado Production Development in Asia and the Pacific. May I take this opportunity to extend to all of you warm greetings on behalf of the Director-General of FAO, from my colleagues in the Regional Office and myself. Special thanks are due to you all for gathering here to contribute to this Meeting.

I am happy to see the positive response which we have received from scientists working on avocados in the Asia-Pacific Region. Considering the important role which this crop can play in food and nutrition security of the Asia-Pacific countries and the need for inter-country cooperation on problems of common interest, we have decided to hold this Expert Consultation in order to elaborate on issues relating to the development of this crop in the region. While appreciating your response to our invitation, I hope this meeting will prove to be productive and beneficial for all the participating countries.

Avocados have been known for many years, dating back at least to 1519 when Hernando Cortez, Spanish soldier of fortune, was the first white man to set foot in Mexico City. However, the first written account of the avocado, so far as is known, is contained in the report of Gonzalo Hernandez de Oviedo (1526), who saw the tree in Colombia, near the Isthmus of Panama.

Mexico, Central America and northern South America are considered to be the centres of origin of avocados. Archaeological and other evidence indicates that avocados were cultivated there in very early times, possibly some 6000 years ago. They were there as nature presented them, a heterogeneous mixture of seedling trees. They were not commercially exploited until the first years of the present century, when their potential for commercialization was developed by Californians. It was in this state that avocado growing became a recognizable industry. The crop has a wide adaptability, and avocados are now grown in most tropical and subtropical countries. Yields up to 35 tonnes/hectare have been obtained in South Africa from high-density planting of avocados.

It is worth mentioning something more about the avocados in California. The California avocado industry goes back to Puebla, a city 128 km from the Mexican capital. Carl Schmidt, from California, visited Mexico City, Puebla and Atlixco in 1911 to search the Mexican market place for avocados of outstanding quality and to locate the trees from which they came. He collected budwood from the best trees and shipped it to Atladena, California. Many selections were not well-adapted to California conditions, but one which Schmidt had selected from a tree in the garden of Alejandro Le Blanc flourished. Its strength was officially recognized when it survived the great freeze of 1913 and it was named 'Fuerte' –

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Spanish for vigorous and strong. The 'Fuerte' tree that Schmidt found in Atlixco became the mother tree for California's avocado industry.

Avocado is one of the finest salad fruits. It is a good source of vitamins (A, B, C, E, folacin, niacin etc.) and minerals (iron, magnesium, potassium etc.). Purseglove (1968) considered the avocado as the most nutritious of all fruits. Many horticulturists are accustomed to view the avocado as one of the greatest undeveloped sources of nutritious food which the tropics offer at present. However, while many people view the avocado as a possibility, to many others it is a realized possibility. 'Four or five tortillas (corn cakes), an avocado, and a cup of coffee, - this is a good meal', say the Indians of Guatemala.

There are many reasons to believe that eventually the avocado will be as familiar to Asian housewives as the banana is today. However, at present, the avocado is not popular in the Asia-Pacific region. The great majority of the population do not appreciate this fruit. This is because very few people in the region are aware of the merits of this unique fruit.

It is high time for the countries of the region to start giving consideration to commercial avocado culture. The avocado has to be regarded as a fruit of great commercial possibilities. Some scattered plantations in certain countries of Asia have demonstrated excellent growth and heavy bearing of the trees. There is room for much more production in the region, but only of the best varieties that can be grown. At the same time the people in the region must become aware of the avocado and its merits, and there is, therefore, a need to encourage, develop and implement an awareness programme about avocado.

Development of the avocado industry in the region will require a concerted effort on the part of the governments and the growers. Collaboration between countries of the region is important and rewarding. In view of the commonality of problems and issues, sharing of information and experience on various aspects of avocado production could lead to quicker and more remunerative results.

Distinguished participants, we in FAO look forward to your advice and guidance concerning an appropriate strategy for the development of the avocado industry in the region. I can assure you of our full support to your efforts.

I wish you success in your present endeavour and a very pleasant stay in Bangkok.

AVOCADO PRODUCTION IN AUSTRALIA

Anthony W. Whiley *

1. INTRODUCTION

Avocados are recorded growing in Australia as early as the mid-eighteenth century. However, the modern-day industry dates from 1928 with the first importation of named varieties from California. Small quantities of fruit were first offered for sale on major metropolitan markets during the mid-1930s where they were accepted for their novelty value.

The industry initially developed on the subtropical eastern coast of Australia, in southern Queensland and northern New South Wales (latitude 25°S - 30°S). Production has since spread to all other mainland states where the crop is grown from latitudes 17°S to 34°S. During the early years of development, the avocado industry could only be considered as a 'backyard' enterprise. Individual growers had small numbers of trees and inevitably were engaged in some other form of horticultural pursuit for their major income source.

During the late 1960s and early 1970s, the fruit became popular in up-market restaurants and hotels where it was seen as a luxury item. In 1974, abnormally high summer rainfall affected the major production areas of Queensland and New South Wales, decimating the industry. It was estimated that 50 per cent of all bearing trees in these two states died by drowning or *Phytophthora* root rot, while most of the survivors went into severe root rot decline. Subsequently high market prices resulted in large numbers of trees being planted during the mid to late 1970s. These continued until 1987 when prices fell in response to a fully supplied market, and the previous optimism was replaced by a concern of over-production. Growth in the industry has been more moderate during the 1990s.

2. PRESENT SITUATION OF AVOCADO CULTIVATION

2.1 Production areas

Avocado production in Australia enjoys a wide geographic distribution growing between latitudes 17°S (500 m asl) and 34°S. This environmental diversity, combined with selected varieties, gives fruit supply to markets on a year-round basis. Production peaks from June to November with lighter supplies during the summer months. Queensland and New South Wales are the largest producing states with an estimated 60 and 30 per cent, respectively. The balance of the crop is grown in Victoria, South Australia and Western Australia where plantings are more recent but tree numbers are rapidly increasing, buoyed by higher prices for summer production.

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2.2 Production statistics

The total Australian avocado production of 1996/97 was estimated at 18,000 tonnes with the fruit mainly sold in domestic markets. There is no developed export of avocados from Australia at present, though a programme to send fruit into New Zealand to complement their out-of-season time of the year is underway. Farm size is variable and ranges up to 100 hectares with most growers controlling between 5 and 15 hectares of trees. The better growers in the more favourable environments average about 20 tonnes/hectare while the highest recorded commercial yield for one season is 50 tonnes/hectare. An industry average for bearing trees is estimated at 7 tonnes/hectare.

2.3 Cultivars

The industry is based on Mexican/Guatemalan race cultivars thereby differing from the tropics where avocado production is based on West Indian race cultivars. The main cultivars grown in Australia in order of maturity are:

'Shepard': a cultivar developed in California. It is a precocious, heavy-cropping, semi-dwarf tree with green pear-shaped fruit. The flesh is pale yellow when ripe with a smooth, buttery texture. It has a B-type flower pattern and is sensitive to the environment during flowering with a requirement that night temperatures do not fall below 12°C. The fruit has moderate disease and pest resistance and it is the earliest maturing cultivar. Its major disadvantage is the large seed size.

'Fuerte': the main cultivar in Australia from the 1960s through to the late 1980s, but today of lesser importance and gradually being replaced by other cultivars. Developed in California it is a green-skinned, pear-shaped fruit maturing shortly after 'Shepard'. It has a B-type flower and its cropping is more reliable in warmer climates.

'Sharwil': selected as a new cultivar in Queensland and thought to be predominantly Guatemalan with some Mexican race genes. The tree is vigorous with the potential to set heavy crops of smooth, green, pear-shaped fruit. Flesh quality is excellent and seed size typically 13 - 15 per cent of the fruit. The cultivar has a B-type flower pattern with a sensitive reaction to environment (temperature x flowering). 'Sharwil' is a mid season-maturing variety coming in after 'Fuerte'. It has become the most important cultivar of Hawaii, and is more disease and pest resistant than Fuerte.

'Pinkerton': a Mexican/Guatemalan hybrid. It was bred in California and crops heavily and reliably in most districts in Australia. It has an A-type flower and the tree is semi-dwarf in habit. Fruits are green-skinned with a slight pebbly texture and a long neck.

'Hass': currently the most important cultivar and grown in all districts in Australia. 'Hass' was selected in California. The tree is upright and vigorous with an A-flower type. It produces ovate fruit with a pebbly skin that changes from green to black when ripening. 'Hass' is a late-maturing variety with some tolerance to fruit diseases and pests. Crops are heavy and reliable as long as fruits are not hung too late. Fruit size tends to be small in the warmer areas of production.

'Reed' and 'Wurtz': two late maturing cultivars of minor importance. 'Reed' is a prolific-cropping cultivar with large, round, green-skinned fruit of excellent quality. It is a

cultivar of the Guatemalan race and trees are upright and semi-vigorous. 'Wurtz' has a pear-shaped, green-skinned fruit which it bears on a densely foliated, semi-dwarf tree with a weeping habit. Cropping can be strongly biennial.

2.4 Rootstocks

The Australian avocado industry has been developed on seedling Guatemalan rootstocks. This was by way of convenience rather than choice, as a significant population of seedling trees existed as a relic from the days of unregulated importation. Nevertheless, for the most part they have served the industry well. However, with the increased sophistication in orchard management, there is an interest to narrow the genetic diversity to a few elite lines. Mexican race rootstocks were introduced into the industry during the early 1980s and these are serving as a comparative basis for evaluation and selection.

3. PRODUCTION OF PLANTING MATERIAL

3.1 Accreditation scheme

To reduce the spread of *Phytophthora cinnamomi*, the root rot fungus, and avocado sunblotch viroid, the Australian avocado industry developed a disease-free nursery scheme for the production of trees. The scheme is known as the Avocado Nursery Voluntary Accreditation Scheme (ANVAS) which is operated under strict hygiene. It is a voluntary scheme but carries the prestigious endorsement of the Australian Avocado Growers Federation. Strict guidelines are adhered to which include pasteurisation of potting media, all plants grown on raised benches, dust suppression in the nursery and a disease-free water supply. Plants are inspected and tested twice each year by government inspectors and nurseries not reaching the required standard are expelled from accreditation until they correct their problems. Nurseries participating in the scheme offer trees for sale that are certified free of *Phytophthora* root rot and avocado sunblotch viroid and that are true-to-type with respect to the variety offered for sale.

3.2 Propagation

Avocado production in Australia is based on named varieties so that all trees sold are grafted. Rootstocks used are either seedlings of the Guatemalan (Velvick) or Mexican (Duke 7) races; however, there is increasing interest in using vegetatively cloned rootstocks of elite selections. Cloning is based on the mother-seed principle where a vigorous seedling is grown and the rootstock scion grafted as soon as practical. Once growth begins on the rootstock scion the plant is moved to a dark room and the shoot etiolated in darkness. A metal band is loosely fitted around the etiolated shoot that is then covered with soil, allowing the new growth to develop in full sunlight. Once the new growth is large enough the desired variety is grafted. As the plant continues to grow, the metal band cuts into the etiolated rootstock material and roots begin developing above the band. Eventually the mother seed is starved and cut off from the plant.

4. ESTABLISHMENT OF ORCHARDS

4.1 Land preparation

Avocados are grown on a wide range of soil types from free-draining, red basaltic loams, previously supporting rain forest, to eroded coastal sand dunes. Where soil depth is marginal (less than one metre), mounding along the row is employed to increase the effective root zone and improve drainage. Prior to planting a new orchard it is recommended that any tree stumps or large roots be removed to reduce the risk of *Armillaria* root rot developing and spreading to young trees. The pH of the soil should be checked and adjusted to about 5.5 with lime or dolomite if necessary. Liming materials should be applied before the final cultivation to ensure that they are well incorporated into the soil. Deep ripping is recommended to improve sub-surface drainage. Zinc is the most common trace element deficient in Australian soils and if required is also incorporated during final soil preparation.

Individual tree sites are prepared by hand about 3 months prior to planting. At each planting site 200 to 300 grams of superphosphate along with 10 to 15 litres of poultry manure are dug in to a depth of 300 millimeters over a one square metre area. The 'Pegg philosophy' - cover-cropping and mulching as an integral part of root rot control - is practised by a significant proportion of growers in subtropical areas during the establishment phases of the orchard. Invariably these properties have higher productivity.

4.2 Planting time

Planting time varies depending on the district as it is tied in to climatic conditions. In subtropical Australia the most-favoured planting time is the autumn when temperatures are warm enough for establishment but not so hot that trees stress and sunburn. Root growth continues through the winter and trees grow away strongly in spring. However, at more southern latitudes the risk of frost damage to young trees through the winter is high and planting is favoured during spring.

4.3 Spacing

Depending on the value of land, either intensive or extensive planting densities are used by Australian growers. Intensive planting densities rely on the principle that close-planted trees will be thinned as they begin to crowd so the mature orchard will have a reduced number of trees compared with the initial number. Initial tree numbers planted are about 300 per ha but once thinned are reduced to about 170 per ha. Various spacing configurations are used including 6 x 6 metres and 7 x 5 metres. The advantage of intensive-planted orchards is that greater cash flow is generated in the early years of the orchard that more than compensates for the extra costs of establishment. In extensive-planted orchards, trees are planted in the position they will occupy for the life of the orchard. One of the most popular spacings in extensive-planted orchards is 9 x 7 metres which gives a tree population of around 150 trees/hectare.

4.4 Planting

It is normal prior to planting to install irrigation, allowing one sprinkler for each tree position. The site (approximately one square metre) is dug over, incorporating 100 grams of a complete analysis fertilizer and a hole dug to accommodate the root ball. After planting it

is good practice to cover the one square metre planting site with an open mulch, which reduces water loss and suppresses weed growth.

5. CARE AND MANAGEMENT OF ORCHARDS

5.1 Training and pruning

There is little tree training practised on avocados during their establishment years apart from tipping the central shoot to encourage branching when trees are received from the nursery. Tipping growing points of trees in their second year to increase tree complexity is carried out by some farmers but there is little evidence of benefits.

Controlling tree growth in mature orchards remains the biggest challenge of orchard management. Being terminal flowering trees, avocados need to grow each year in order to remain productive, hence trees become larger. To maintain orchard access between rows, major limbs are periodically removed, cutting back to the main trunk. Similarly, to contain tree height major limbs are lopped from the top of the tree when necessary. In some orchards, trees are not pruned at all until their size is so great that they are uneconomic to manage. They are then stumped to approximately one metre high and allowed to regrow. After this treatment they are back in full production within two years.

Current research is investigating the use of mechanical pruning equipment to hedgerow trees at strategic times during the summer. Regrowth is then sprayed with a growth inhibitor (uniconazole) to suppress shoots and encourage floral initiation. Conclusive results from this research are not yet available.

5.2 Crop nutrition

Crop nutrition is based on critical leaf levels to predict requirements for the following season. Critical leaf levels established for avocado are presented in Table 1.

If required, most nutrients are applied in the spring or summer, usually by fertigation. Generally, however, nitrogen is applied after the spring fruit drop is completed. This is to reduce the risk of promoting too strongly spring shoot growth at the expense of the developing fruit. AVOMAN, a computerised orchard management programme, provides a customized nutrition programme for each block of trees in an orchard integrating the past cropping history of the trees, current crop load, rainfall and nutrient status.

Table 1. Critical leaf levels of nutrients for avocado production. Levels are determined from sampling fully matured leaves from non-fruiting shoots at the end of summer when trees are in a quiescent phase.

Nutrient	(%)	(mg/kg)
N	2.4-2.8	
P	0.08-0.25	
K	0.75-2.0	
Ca	1.0-3.0	
Mg	0.25-0.80	
S	0.20-0.60	
Na	<0.25	
Cl	<0.25	
Mn		30-500
Fe		50-200
Cu		5-15
Zn		40-80
B		40-60

5.3 Orchard floor management

Most orchards establish a grass sward between rows that are kept mown. However, to reduce competition, grasses and weeds around trees are sprayed with Round Up. Mulches of straw, cane tops or sorghum hay are placed around trees to suppress weed growth and to improve root health. Research has shown that fruit size can be increased by as much as 15% by using a mulching programme around trees.

5.4 Irrigation

The avocado is a tree of rain forest origin and requires regular watering to maintain high yields. Most orchards in Australia have undertree mini-sprinklers to supplement rainfall and to apply nutrients to the trees (fertigation). Water monitoring is by either tensiometers or the more sophisticated electronic monitoring devices that provide a continuous picture of the water status of the root zone. When using tensiometers it is usual to maintain soil metric potential between -40 and -10 kPa at 300 mm depth.

Water use during the winter months falls away but there is a rapid increase in requirement as the trees come into flower during early spring. Water stress during the first eight weeks of fruit growth can lead to reduced fruit size as cell division is retarded. Also, water stress during the natural period of fruit drop at the end of spring, can increase fruit loss, thereby reducing final yield. Ring-neck, a natural cincturing of the pedicle, has been related to water stress during the later stages of fruit maturity, and can reduce fruit size and final yield.

5.5 Pests

Fruit-spotting bug causes fruit blemishes and is active in subtropical areas of

Australia. As it migrates into orchards from surrounding cover it is difficult to control and requires a protective insecticidal programme for the duration of the fruiting season. The red-shoulder or monolepta beetle can cause substantial damage to leaves and fruit if it swarms into orchards. Also migratory, it is difficult to control and daily inspection of trees with spot spraying of swarms is the most effective method to contain this pest. Queensland fruit fly in eastern Australia and Mediterranean fruit fly in west Australia can damage fruit, but are of minor importance. Several species of leaf-webbing caterpillar can cause damage to fruit in the autumn months and can be controlled by strategic applications of targeted insecticides. Integrated Pest Management systems developed for citrus orchards are gradually being introduced into avocados.

5.6 Diseases

Phytophthora root rot caused by *Phytophthora cinnamomi* is a major international disease of avocado and is present in all countries producing this crop. All areas in Australia producing avocados are affected by this disease. Phytophthora root rot is successfully controlled by trunk injection with potassium orthophosphonate using a 20% a.i. solution which is injected at the rate of 15 ml per metre of tree diameter. Despite the spectacular success of phosphonate treatments, an integrated approach of biological and chemical control is still recommended in the high-risk subtropical areas of northern New South Wales and Queensland. Anthracnose, a serious fruit problem in most environments, is controlled by regular spraying with copper-oxychloride and a post-harvest treatment of prochloraz (Sportak). Verticillium wilt is a disease of lesser significance. It is a soil-borne disease which attacks the vascular system but seldom kills plants, and there is no effective fungicidal treatment.

6. HARVESTING OF FRUIT AND ORCHARD YIELDS

6.1 Maturity standards

Fruit of all cultivars must reach a minimum of 21% dry matter and ripen naturally without shrivelling before it can be harvested legally and sold.

6.2 Harvesting

Fruit is hand-harvested from trees when mature using an array of picking aids. On the larger orchards, trees are harvested with the aid of hydraulic ladders (cherry pickers) while on the smaller properties picking poles are used to reach fruit. For most cultivars, fruit needs to be clipped with a 'button' retained on the pedicle end. This reduces the risk of stem-end rot invading the fruit as it ripens. Fruit is picked into large bins usually mounted on trailers to facilitate their movement to the packing shed. It is important to keep the fruit out of direct sunlight after picking to prevent it from heating.

For early-maturing cultivars and those with a fruit size problem, fruit is normally picked over two harvests removing the larger fruit first hence allowing the smaller fruit to grow. Generally, late hanging of fruit, which is often practised to market when prices are higher, drives the trees into biennial bearing. Due to the number of cultivars and the wide range of latitudes at which the crop is grown, avocados can be harvested year-round in Australia although the peak of production is during the winter and early spring months.

6.3 Yields

Yields are variable depending on the district and cultivar. Growers following 'best commercial practice' can sustain yield in mature orchards at 18-23 t/ha. However, the Australian industry as a whole has an average yield of only 7 t/ha though this figure incorporates production from young trees as well as mature orchards.

7. MARKETING

On reaching the packing shed, fruit is passed through a spray treatment of Sportak (prochloraz) to control anthracnose. Fruit is then size and quality graded, packed into 6 kg trays and pre-cooled prior to transportation. Fruit quality is determined by its freedom from insect, wind or hail marks. Most fruit is shipped in refrigerated trucks by road to markets in major cities.

7.1 Buyers

Traditionally, growers have marketed their fruit through agents/merchants. In major cities, however, over the last 10 years there has been an increase in direct marketing to the big chain stores which now sell about 80% of Australia's fresh fruit and vegetables. This style of marketing is best suited to big growers who can deliver a consistent long line of fruit. To gain market share, smaller growers are now coming together in cooperative packhouses where they can offer the same supply as the larger producers.

7.2 Pre-ripening

Market research has shown that more avocados are sold if they are offered to the consumer in a ready-to-eat condition. This has led to a system of pre-ripening fruit prior to stocking retailer shelves. Fruit is gassed with ethylene at a central location and held at 21°C until it is sprung, then taken to the retail point of sale.

7.3 Quality assurance

Food safety has become an important issue in Australia with strict guidelines now being set by the food industry. The major chains invest heavily into promoting brand names and cannot afford adverse publicity that might arise from product exceeding the legal limits set for pesticide residues. Hence, growers with direct marketing to the major chains are required to maintain a production schedule documenting all procedures carried out, from field operations to delivery to the point of wholesale. This level of documentation is also useful to the grower, who is able to check the success of the production and postharvest handling strategies implemented, and make changes where necessary.

7.4 Promotion

Along with a compulsory R, D & E levy, the Australian avocado growers pay a compulsory promotional levy of 3 cents/kg. The levy is collected by the Australian Horticultural Council and their marketing experts put together a promotional budget each year that is agreed by industry. Promotion is mostly limited to the printed media, leaflets and point-of-sale demonstrations on ways to use the product.

8. POTENTIAL FOR AVOCADO PRODUCTION

The greatest opportunity to increase Australian avocado production is to improve fruit quality on the domestic market. Currently, a significant quantity of fruit is thrown out at the consumer level due to an unacceptably high incidence of fruit rots that develop during ripening. Research has identified fruit calcium levels as a significant factor affecting fruit quality and reducing post-harvest rots, and methods are being researched to increase the level of this nutrient in fruit.

9. CONSTRAINTS IN AVOCADO PRODUCTION

Major constraints faced by the Australian avocado industry are poor fruit quality, the relative isolation from large export markets and the availability of suitable soil and water resources. The lack of confidence in the product by consumers is limiting opportunities to develop a larger domestic market, hence industry expansion will lead to an oversupply with a reduced return to growers. Avocado is currently not a favoured fruit in most Asian countries to which Australia could export fruit without major quarantine issues restricting entry. Fruit-fly disinfestation research is almost complete and if commercially successful will open some markets that can be exploited economically, e.g. New Zealand and Japan. Most of the suitable avocado soils along the subtropical coast of New South Wales and Queensland are currently growing sugarcane where farming traditions are entrenched. This limits the opportunities for expansion of the crop.

Human nutrition: the avocado is rich in vitamins C, E and beta-carotene. It is also a rich source of potassium and dietary fibre. The Australian avocado industry has been very aware of the value of avocado for human nutrition and has promoted this aspect of the fruit to consumers. Also the industry commissioned research by a leading cardiologist who found that the monounsaturated fats occurring in avocados reduce blood cholesterol while preserving the level of high-density lipoproteins which protect the blood vessel walls from atherosclerosis. This research has led to the Australian Heart Foundation recommending avocado as a dietary source of fat.

10. RESEARCH, DEVELOPMENT, EXTENSION AND GROWERS' ORGANIZATION

The Australian avocado industry has a strong research and development programme funded by a national levy of 1.3 cents/kg collected at the wholesale point. Levies are administered by the Horticulture Research and Development Corporation (HRDC), a federal government agency established to support horticultural R, D & Extension programmes. For every dollar raised by the industry levy, HRDC contributes another dollar. Industry priorities are set at workshops held every five years where growers and government research and extension officers develop a forward plan. Generally, research projects are funded for a three-year term and may be renewed if required. The industry takes a proactive approach and identifies priority research areas when project applications are called each year. There are two major projects being funded currently by the avocado industry. These are 'Canopy health and management' and 'Field control of post-harvest diseases'.

The avocado industry has just finished funding a six-year programme on technology transfer at the cost of AUS\$1.2 million. From this project two software packages have been produced: AVOMAN which is a highly customized orchard management programme and AVOINFO which is a bibliographic database. There has been a high uptake of these software programmes by the industry.

The Australian avocado growers are served by a national body, the Australian Avocado Growers' Federation (AAGF). This organization has delegate representatives from each state producing avocados. Representation is weighted in favour of Queensland and New South Wales, the two states which dominate production.

Within its limitations the AAGF coordinates promotional effort for avocados in the major Australian markets and acts as a national voice on factors important to the industry. It also assumes the responsibility to hold the biennial seminar and field days where the latest production trends, technology and marketing prospects are discussed. Organization structures differ between states, but in areas of significant grower numbers district associations are formed which serve to keep their members informed on new technology and marketing developments.

11. CONCLUSIONS

The Australian avocado industry has a strong political structure, with representatives from each of the producing states. It is member industry of the Australian Horticultural Council and the Horticultural Research and Development Corporation with mandatory levies collected for promotion and R, D & E by each of these bodies. Compared with other subtropical and tropical fruit crops in Australia, it is a technologically advanced industry funding innovative R & D programmes such as AVOMAN and AVOINFO. The industry has a strategic plan for the future and a R, D & E programme to assist it in reaching its goals.

Production is mostly targeted at the domestic market though research into disinfestation is assisting in overcoming quarantine barriers in the potentially lucrative markets of Japan and New Zealand. Like most primary producing countries of the western world, production costs are escalating faster than gross returns and to remain competitive growers have the need to increase production efficiency. To achieve this, investment into the development of new technology must continue, particularly plant breeding, rootstock selection, orchard management, disease control, IPM and post-harvest handling.

AVOCADO PRODUCTION IN CHINA

Liu Kangde and Zhou Jiannan*

1. INTRODUCTION

China has some 80 years history of avocado introduction and trial planting. Avocado was first introduced into Taiwan in 1918 and then into Guangdong in 1925. Nowadays, avocado is reported to be successfully planted on a trial basis in Guangdong, Guangxi, Hainan, Fujian, Sichuan, Yunnan, Zhejiang, Guizhou, etc. (Cai, Liu, et al., 1998).

The avocados cultivated in China were generally the progenies of some unselected poor-quality seedlings of unknown origin. It was not until 1985 that high yielding varieties of avocado such as Hass were introduced for trial planting by the Guangxi Bureau of State Farms, etc. Collection, introduction and selection of avocado has been conducted by the College of Agronomy, South China University of Tropical Agriculture, since 1986 and more than 80 varieties have been selected. Huang Wenzhen and Liu Kangde established a 33.3 ha experimental plot of avocado and a nursery in Baisa County, Hainan, in 1989, to determine commercial cultural techniques (Liu, Zhang, et al., 1993).

2. PRESENT SITUATION OF AVOCADO CULTIVATION

Avocado is grown in Guangxi, Hainan, Yunnan, Guangdong, Guizhou, Fujian, Zhejiang (Wenzhou city) and Sichuan (Panzhihua city) in China. There has been no sizeable commercial production up to now due to various reasons. The largest tract of cultivation in China is the avocado base in Baisa County, Hainan, covering 33.3 ha. Guangxi has the largest area with scattered avocados. Prof. He Guoqiang, Guangxi Staff University of State Farms, reported that Guangxi used to grow 133 ha of avocado in more than 50 counties/cities, of which 66 ha were under commercial production; the largest avocado orchard was in the Shanyu State Farm, covering 20 ha.

Commercial production of avocado is just at the early stage and the planting area is very limited. No data on avocado is available in the local statistical yearbooks. Avocado sets flowers after 2-3 years of planting and yields 35-103.5 kg/tree at the age of 7-8 years, according to the reports of trials in different locations. The total area under avocado cultivation in China was estimated to be 133 ha in 1998 with a production of around 1,000 tonnes.

Most avocados planted before 1985 were seedlings, and budded and grafted plants of desired varieties have been used only in the last ten years. To date, China has selected more than 70 avocado varieties and more than 10 elite lines. Some of the commercial varieties such as Lula, Pollock, Booth 7, Booth 8, and the local variety ST₃, have good performance in Hainan and other provinces. The varieties used in trials, at present, are indicated in Table 1.

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Table 1. Major Avocado Varieties Used in Trials

Race	Varieties	Remarks
Mexican race	Bacon, Zutano, Duke, Mexicola	Trial in Hainan
Guatemalan race	Hass, Nabal, Reed, Taylor, Linda	>>
West Indian race	Pollock, Sharwil, Murashige	>>
Hybrids	Fuerte, Lula, Booth 7, Booth 8, Hall	>>
Local selections	ST ₃ , ST ₆ , ST ₉ , S ₁₀	>>

3. PRODUCTION OF PLANTING MATERIALS - NURSERIES

There were no state-owned commercial nurseries in China until recent years. Generally, nursery plants were raised privately by the farmers in state farms. It is since the late 1980s that commercial nurseries have been established separately by the South China University of Tropical Agriculture and the Guangxi Staff University of State Farms, and provide high-quality planting material, mainly in Hainan, Guangdong and Guangxi.

Planting materials used in China are generally polyethylene bag-raised seedlings and budded and grafted plants. Polyethylene bag seedlings were the major planting material before 1985, and polyethylene bag budded and grafted plants have been commonly used since the 1980s. Bare-rooted nursery seedlings have a low success rate of survival and, basically, are not used for planting commercially.

The commonly used vegetative propagation methods include patch-budding, cleft-grafting and side-grafting. Thirty-day-old seedlings are used as stocks for cleft-grafting and satisfactory results are obtained. The grafted plants are ready for planting out after 6-9 months of seed germination, when they grow 50-60 cm high. This mini stock-grafting method shortens the propagation duration by one year as compared to the patch-budding of polybag older stocks.

4. ESTABLISHMENT OF ORCHARDS

Orchards are usually established on gently sloping land with loose soil and good drainage. In areas with strong wind, orchards should be set up against the wind, and windbreaks are necessary. In areas prone to cold injury, orchards are set up on gently-sloping land towards the sun but against wind. Mechanical cultivation is generally practised after slashing and clearing on the gently sloping waste land. Terracing or benching is necessary on the sloping land.

Planting season

Avocado is planted out all the year round in Hainan if irrigation is available. In the cold areas of the mainland the plants are planted between the warm spring and the autumn, prior to the end of the wet season.

Spacing

The spacing varies with climate, soil regime, vigour and growth habit of the varieties. For tall varieties or those with spreading growth habit a wider spacing is given, such as for Fuerte, Linda, etc. For varieties having compact crown (for example Lula) closer spacing is given. The plants are usually planted at a spacing of 4-5 metres to 5-6 metres with 333 - 500 plants/hectare in Hainan. Pruning or thinning is practised when the tree canopy shades the rows, after several years of planting.

Opening of pits and planting

Pits of 80×70×60 centimetres are opened about one month before planting out. Generally, they are opened manually though mechanical pitting has been conducted occasionally in recent years. Surface soil and organic manures then fill the pits after full exposure to the sun. The plants are planted when the weather is cloudy, cool and humid but without rain. The polyethylene bag is removed and the compact root ball is not disturbed. The plants are watered and mulched after refilling and compressing the pits. Interplanting of A and B type varieties should be considered when establishing an orchard.

5. CARE AND MANAGEMENT OF ORCHARDS

Training and pruning

Avocado is trained and pruned based on the characteristics of the varieties. Generally, avocado trees are headed back at an early stage when they are 80 to 100 centimetres high to encourage lateral growth, and the branches are then cut back when they are 50 to 60 centimetres long to form a good framework. The avocado is pruned mainly by removing the dead, weak, crossed and thick branches. The bigger cut ends are sealed to prevent rot and other diseases.

Application of manures and fertilizers

The application dose and proportion of manures and fertilizers are generally based on the soil fertility, tree age, growth and yield. For the young orchards where manures are applied in the pits before planting, fertilizers (mainly liquid N) are applied in frequent low doses. For the mature orchards, mainly N and K fertilizers are applied 3-4 times annually, separately in February to April, April to May, and July to September. P fertilizer and organic manures are mixed and applied before and after avocado fruits are harvested.

Weeding and mulching

Weeds should be controlled in the young orchards. Generally, manual weeding is conducted 3-4 times per annum, together with shallow soil cultivation and fertilizer application. The area around the trunk of the tree is mulched with dead grass or the like to inhibit weed growth, and at the same time to slow down the evaporation of soil moisture, maintaining soil humidity and reducing soil temperature. Legume cover crops such as stylosanthes are intercropped in some young orchards. Glyphosate is used for controlling weeds in the rows of trees not intercropped with cover crops in some young orchards.

Irrigation

Avocado is very sensitive to dry soil. Soil moisture should be maintained in the root zone. Moisture stress gives rise to physiological hindrance, resulting in weak vigour and even defoliation and fruit drop. Avocado sets flowers and bears fruit during December to May, the dry season in most of the southern part of China, hence irrigation is very important. Avocado orchards give a high and stable yield when irrigation is available. Improved irrigation systems such as sprinkle and drip are not used at present. For the orchards with easy access to water, flooding is achieved by water pumping. For the orchards far away from water source, irrigation is carried out using tractors with water tanks.

Control of pests and diseases

Diseases

There are more than ten diseases, such as root rot, collar rot, phytophthora canker, anthracnose (*Colletotrichum gloeosporioides*), stem-end rot (*Dothiorella aromatica*), scab (*Sphaceloma perseae*), etc. Of the diseases, root rot and collar rot are the most serious.

Root rot is the most serious disease of avocado in mature orchards, caused by a fungus, *Phytophthora cinnamomi*. It attacks small roots, thereby causing leaf fall, dieback of branches and tree collapse. The trees infected show symptoms of weak vigour with withered and sagged leaves, yellowish-green leaves, dead twigs and branches, small fruit and seriously scalded branches. The cortex of the infected roots turns black, rots and dies. Some seriously infected trees wither and die. Root rot is aggravated by waterlogged and poorly drained soils. Chemicals such as Alliette, Ridomil, etc. are used as a soil drench, or Alliette as a trunk injection at 0.3 grams/square metre. Phytophthora-resistant rootstocks are also being selected, such as Thomas, Duke 7, etc, but they are not yet used commercially.

Collar rot, caused by *Phytophthora citricola*, is another serious disease of avocado in young orchards in Hainan. It attacks the collar, resulting in retarded growth without flushing and then tree decline or collapse. The affected trees show a symptom of shallow honeycombed rot at the early stage, which then spreads, resulting in exudation of white foam-like or pasty sticky liquid (attracting a mass of ants) and, finally, a ringlike rot and death. The disease occurs after heavy rain caused by typhoon. A survey carried out on 4 hectares of affected plantations in 1989 indicated that the incidence was as high as 22 percent.

For the control of collar rot it is very important to drain the water after heavy rain, prune regularly the drooping branches and maintain good ventilation of the plantations. Alliette (1%) is applied at a solution rate of some 25 kg to the base of the trees in the orchards of high incidence, or to those affected by typhoon. For the affected trees, the soil around the tree base is removed in clear day, and the affected parts are washed by spraying with tap water and, when dry, painted with Alliette paste 2% and refilled with soil. Satisfactory results were obtained by using this method (Shang, Liu, et al., 1996).

Pests

The insect pests include scale insects, mealy bugs and mites, Mexican leaf rollers, aphids, fruit flies, burrowing nematodes, etc. *Serica* sp. is the most important insect

attacking young trees in Hainan. It damages mainly the young leaves and breaks out in April and May. A survey made in May, 1990, indicated that there were 2,853 trees infested with this insect (53.7% of the 5,316 trees surveyed). Dichlorvos (50%, e.c) is used for spraying or as a soil drench at the tree base, and good results are obtained.

6. HARVESTING AND YIELD

Avocado tends to set flowers in February and March in Hainan. The maturity period of avocado varies with varieties. The fruits of local varieties and those of the Pollock variety mature in July and August. Other introduced varieties, such as Lula, Booth 7, Booth 8, etc., mature their fruits at the end of September and mid-October, while Hass matures its fruits in November and December.

Yellow or purple skin (differing with varieties), dark brown wrinkled dry seed coat, and certain minimum oil content reached are considered as indexes for fruit maturity. Fruit maturity may also be estimated by using specific gravity or growth time of the fruit.

Mature fruits are picked manually and carefully to avoid being wounded, and the stalks, some 0.6 centimetres long, are retained, attached to the fruit. Picking is carried out in cloudy cool or clear morning.

The average commercial yield in Hainan is 7.5-15 t/ha. Some varieties, such as Lula, Pollock and the local variety ST₃, give a yield of 15 t/ha and their quality is good, whereas some other varieties such as Hass give a rather low yield of 3-4 t/ha (Table 2). This is probably due to difference in adaptation to climatic conditions. Hass is not suitable for commercial cultivation in Hainan, where temperature and humidity are high.

7. MARKETING

Avocado is in the stage of trial planting and extension. Most of the fruits are sold at low prices in the local markets. Very few fruits are seen for sale in towns away from the orchards. No data on import and export is available.

The fruits for local sale are not treated after harvest. Fruits shipped to the northern parts of China for marketing are handled in two ways: either they are washed with hot water (50°C), packed when cool, and shipped and marketed at ambient temperature, or the harvested fruits are cleaned and stored at low temperature. The recommended temperature for cold storage is 10 to 13°C for the West Indian race varieties, 7 to 8°C for varieties of the Guatemalan race, and 4 to 4.5°C for varieties of the Mexican race. The relative humidity is 80 to 90%. The fruits can be stored for one month at low temperature. The recommended temperature for ripening of the stored fruits is 15 to 21°C.

Table 2. Fruit Characteristics

Variety	Fruit		Pulp			Seed	
	Weight (g)	Appearance	Colour	Fibres	Fat (g/100g pulp)	Weight (g)	Seed/pulp weight (%)
Lula	589	Good	Pale yellow	Few	13.70	84.0	18.0
Pollock	741	Good	Pale yellow	Rather few	6.87	106.0	15.5
ST ₃	420	Good	Yellow	Few	9.82	67.5	14.4
Booth 7	530	Good	Dark yellow	Few	15.50	95.0	22.0
Booth 8	410	Good	Pale yellow	Few	17.70	65.0	17.8
Hass	144	Poor	Pale yellow	Few	17.50	30.0	20.8
Bacon	322	Fair	Creamy	Few	15.30	80.0	27.8
Zutano	264	Poor	Creamy	Few	14.40	56.0	21.2

Note: The figures obtained in 1994 by Liu Kangde, Cai Shengzhong, etc. are the mean value of 10 fruits randomly sampled.

8. POTENTIAL FOR AVOCADO PRODUCTION DEVELOPMENT

China has a great potential for avocado production development. It is estimated that China will have a population of 1.6 billion by the year 2030. It has called the attention of the Chinese government to securing food for the increasing population. Avocado fruit is very nutritious and can be eaten fresh. Avocado products will have a large market when accepted by the Chinese people.

There is a stretch of hilly land suited for avocado planting in the south of China. The tropical and subtropical land covers some 48 million ha in China, distributed in Guangdong, Guangxi, Hainan, Fujian, Yunnan, Guizhou and Sichuan; the land under tropical and subtropical economic crops covers only 6.385 million ha at present. There is also a vast tract of hilly land in the southwest of China, a large part of which is suited to developing tropical and subtropical economic crops such as avocado.

China has good varieties available for the development of avocado production. Research work carried out has resulted in the selection of over 80 avocado varieties; also, appropriate production techniques, including propagation, transplanting, manuring and fertilizer application, control of pests and diseases, harvesting, storage and shipment, have been determined. This can ensure availability of nursery plants and production technology for the development of avocado production in China.

9. CONSTRAINTS IN AVOCADO PRODUCTION DEVELOPMENT

Little awareness of avocado

Avocado is a very nutritious fruit, containing fat, protein, vitamins, minerals and other elements. Most Chinese are not aware of the nutritional value of avocado. Avocado fruits are consumed fresh as are other fruits at present in China. They are neither sweet nor sour and hence less favoured compared to other tropical and subtropical fruits such as litchi, longan, mango, etc. It is hard to popularize a cold dish, sandwich and salad made with avocado. It will take time for the Chinese people to accept avocado, and publicity is necessary.

Difficulty in marketing

The avocado market has yet to be developed since very few people know the nutritional value of this fruit. In the early 1990s, avocados were shipped and marketed in big cities such as Beijing, Shanghai and Guangzhou; however, only some large hotels with foreign cooks showed interest in this fruit. Difficult marketing has given adverse impact to the expansion of the planting area for commercial production.

Avocado has a short storage life under normal temperature. Cold storage and shipment increase cost and farmers will not take the risk of selling their avocado far away in small markets. The industrial demand is very limited and it is hard to stimulate expansion although avocado facecream and soap are produced to some extent. Avocado fruits are marketed locally at low price, discouraging farmers from planting avocado trees.

Natural calamities

Natural calamities include typhoon, hot temperature and cold injury. Typhoon is the major calamity in Hainan, Guangdong and Fujian. Strong wind results in damaging the branches and trunks of the trees, causing poor bearing and low yield. High temperature in the south of Hainan also shows adverse influence on the growth of avocado. Cold injury of avocado occurs in the north of Guizhou, Yunnan and Guangxi. For the development of avocado production, careful selection of varieties for various climatic conditions should be considered.

Weak extension service and dissemination of technology

Avocado orchards were privately owned in the past, and the trees planted were progenies of unknown source without selection. The farmers had very little technical knowledge. The needed production technology for commercial cultivation has been developed by the South China University of Tropical Agriculture and the Guangxi Staff University of State Farms since the late 1980s when good varieties were introduced and trials were instigated. Nursery plants of selected varieties have been distributed for trial planting in some provinces of South China. There are, however, very few people engaged in avocado research. The orchards are widely scattered, and there are very few large-scale commercial plantations, leading to difficulties in extension work and dissemination of technology.

10. GOVERNMENT POLICIES AND PLANS FOR RESEARCH AND DEVELOPMENT OF AVOCADO

Research work on avocado was included in key programmes of the Ministry of Agriculture of China between 1986 and 1995. The Guangxi Bureau of State Farms and the South China University of Tropical Agriculture were entrusted to embark on avocado research work. Scientists were sent to the USA and Mexico for training on aspects of avocado production development. Demonstration plots for commercial cultivation have been established in Hainan, Guangdong and Guangxi. However, very limited financial contribution is made at present by the government to commercial expansion of avocado due to poor marketing. In spite of this, the government encourages companies and farmers to plant avocado for strengthening its publicity.

11. CONCLUSIONS

China has an 80-year history of avocado. The climate and soil in several provinces of south and southwest China are suitable for avocado production. However, there is no large-scale commercial production of avocado in China at present due to various reasons. Also, there are no import and export markets for avocado.

Avocado is planted at present mainly in Hainan, Guangdong, Guangxi, Yunnan and Fujian provinces. However, there is a larger tract of hilly land in south and southwest China suitable for avocado development.

China has a large population with limited cultivated land. To secure food for the increasing population, avocado has a role to play as a source of food and nutrition. Avocado

will have a great potential market when substantially more Chinese people become aware of its nutritional value, and accept it. The major constraints to the development of avocado production are little awareness of its nutritional value and difficulties in marketing.

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AVOCADO PRODUCTION IN INDIA

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1. INTRODUCTION

Avocado is a native of tropical America. It originated in Mexico and Central America, possibly from more than one wild species. The early Spanish explorers recorded its cultivation from Mexico to Peru but it was not in the West Indies at that time. It was introduced into Jamaica in 1650 and to Southern Spain in 1601. It was reported in Zanzibar in 1892. It was first recorded in Florida in 1833 and in California in 1856.

Avocado is the most nutritive among fruits and is regarded as the most important contribution of the New World to human diet. The fruit is relished by some people, but not by others. The pulp is rich in proteins (up to 4%) and fat (up to 30%), but low in carbohydrates. The fat is similar to olive oil in composition and is widely used in the preparation of cosmetics. Avocados have the highest energy value (245 cal/100 g) of any fruit besides being a reservoir of several vitamins and minerals (Table 1).

Avocado is mainly used fresh, in sandwich filling or in salads. It can also be used in ice creams and milk shakes and the pulp may be preserved by freezing. Three antifungal compounds have been isolated from the peel extracts of immature fruits of the Green cultivar.

Table 1. Chemical Composition of Avocado Fruit (per 100g of edible portion)

I. General Composition		III. Minerals (mg)	
Energy value (cal.)	245.0	Calcium	10.00
Protein (g)	1.7	Chlorine	11.00
Fat (g)	26.4	Copper	0.45
Total carbohydrates (g)	5.1	Iron	0.60
Crude fibre (g)	1.8	Magnesium	35.00
		Manganese	4.21
		Phosphorus	38.00
II. Vitamins (mg)		Sodium	368.00
Vitamin A as carotene	0.17	Sulphur	28.50
Ascorbic acid	16.00		
Niacin	1.10		
Riboflavin	0.13		
Thiamine	0.06		

Source: Madhav Rao and Abdul Khader, 1977

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2. PRESENT SITUATION OF AVOCADO CULTIVATION

2.1 Major areas where avocados are grown

Avocados can be grown on a wide range of soils, but they are extremely sensitive to poor drainage and cannot withstand water-logging. They are intolerant to saline conditions. Optimum range of pH is from 5 to 7. Depending on the race and varieties, avocados can thrive and perform well in climatic conditions ranging from true tropical to warmer parts of the temperate zone.

In India, avocado is not a commercial fruit crop. It was introduced from Sri Lanka in the early part of the twentieth century. In a very limited scale and in a scattered way it is grown in Tamil Nadu, Kerala, Maharashtra, Karnataka in the south-central India and in the eastern Himalayan state of Sikkim. It can not tolerate the hot dry winds and frosts of northern India. Climatically, it is grown in tropical or semitropical areas experiencing some rainfall in summer, and in humid, subtropical summer rainfall areas.

2.2 Varieties

All three horticultural races adapted to tropical and sub-tropical conditions i.e. West Indian, Guatemalan and Mexican have been tried in India. The cultivars of West Indian race are grown in localized pockets in Maharashtra, Tamil Nadu and Karnataka. In tropical and near-tropical areas, only West Indian race is well-adapted but its hybrids with Guatemalan (e.g. Booth selection) perform well and are considered valuable for extending the harvest season. In less tropical regions, hybrids of Guatemalan with Mexican race predominate since they combine the cold hardiness of the latter with the superior horticultural traits of both and also bridge the two seasons of maturity. In the eastern Himalayan state of Sikkim, avocado has been introduced successfully in hill ranges with an altitude of 800 to 1,600 metres. Both the Mexican and Guatemalan races are grown successfully in Sikkim. In avocado-growing areas of Sikkim, temperatures range from 12 to 30°C with an average annual rainfall of 2,000 millimetres. The Mexican race is cultivated on mid-altitude hills (pH 5-6).

The characteristics of the major avocado races are:

- a) Mexican race: Small (250 g) fruit type, ripening 6 to 8 months after flowering. Fruits have thin smooth skin with a large seed fitting loosely in the central cavity. Oil content is up to 30 per cent in the fruits. Trees of this race are cold hardy.
- b) Guatemalan race: Fruits fairly large, weighing up to 600 g and borne on long stalks. The fruits ripen 9-12 months after flowering. Fruit skin is thick and often warty. Seeds, held tightly in the hollow of the fruit, are small. The oil content in fruits ranges between 8 and 15 per cent.
- c) West Indian race: Fruit medium in size and the fruit skin smooth, leathery and glossy. Fruits are borne on long stalks and require up to 9 months for ripening from the date of flowering. Its seeds are large, fitting loosely in the cavity. The oil content of the fruit is low (3-10 per cent). This race is suitable for warm tropical climates.

The varieties Fuerte, Bacon, Zutano, Hass, Booth 7, Booth 8, Sharwil and Ettinger are reported to be promising. The varieties Pollock, Waldin, Nabal, Linda, Puebla, Gottfreid, Collins, Booth 8 and Fuerte are recommended for commercial cultivation.

The varieties that are cultivated in India go by several names, such as Purple, Green, Fuerte, Pollock, Peradeniya Purple Hybrid, Trapp, Round and Long. Among the several existing varieties, perhaps Fuerte is the most widely grown, but it is regarded as unsuitable for the tropics. The Purple and Green varieties were introduced into India from Ceylon in 1941.

The following varieties have been introduced at the Fruit Research Station, Kallar, Tamil Nadu: Long, Round, Fuerte, Pollock, Peradeniya Purple Hybrid, Shambaganur and Trapp.

The performances of avocado varieties in the Sikkim state are as follows:

Fuerte: Grown successfully in the mid-altitude hills of Sikkim. Fruits, pyriform, weight between 200 and 400 grams each.

Pinkerton: An established variety from California, USA, having pyriform green fruits. The fruit weight varies from 200 to 400 grams.

Green: A successfully grown variety of Guatemalan race with oval-shaped, greenish or light green fruits. Fruit size is similar to Fuerte or Pinkerton.

Hass: Also suitable for Sikkim, with fruit at maturity being purple in colour and medium in size.

3. PRODUCTION OF PLANTING MATERIAL

In India, avocado is commonly propagated through seeds. The viability of seeds of avocado is quite short (2 to 3 weeks) but this can be improved by storing the seed in dry peat or sand at 5° C. Removal of seed coat before sowing hastens germination. In Sikkim, all the trees grown are seedlings in origin. The seeds taken from mature fruits are sown directly in the nursery or in polyethylene bags. When 6-8 months old, the seedlings are ready for transplanting. Such seedling trees at 10-15 years produce 300 to 400 fruits. Vegetative propagation by means of budding or grafting has resulted in establishment of selected varietal clones. Mexican race is reported to provide almost all of the rootstock requirements in California. Generally, it is used also in Israel and South Africa. The Guatemalan race is more sensitive to cold and has also proved more susceptible to high pH chlorosis and to *Verticillium* wilt. West Indian stocks are preferred in warmer regions or where salinity is a problem. Need of *Phytophthora*-resistant rootstocks is recognized as the most important factor for the success of its cultivation. At the Fruit Research Station, Kallar, in the Nilgiri Hills of Tamil Nadu, layering as well as inarching gave up to 75 per cent success, while in West Bengal chip-budding is reported to be successful. In India, presently, there is no commercial nursery engaged in vegetative propagation of avocado, nor is there any initiative either at governmental or private level to undertake nursery production of avocado planting material.

4. ESTABLISHMENT OF ORCHARDS

If an avocado plantation is to be established in a relatively new area, the varieties to be selected for planting should belong to both A and B groups and their flowering must overlap. The proportion of A and B group varieties can be 1:1 or 2:1.

Avocado is planted out to a distance of 6 to 12 metres depending on the vigour of variety and its growth habit. For varieties having a spreading type of growth, like Fuerte, a wider spacing should be given. In areas prone to excess water, they should be planted on mounds as avocados cannot withstand waterlogging. In Sikkim, a planting distance of 10 x 10 metres on hills slopes (on half-moon terraces) is preferred and planting is done in June-July. Pits of 90 x 90 centimetres are dug during February-March, and filled with farmyard manure and top soil (1:1 ratio) before planting. In Coorg, a region of Karnataka state, they have been planted also as one of the mixed crops in a primarily coffee-based cropping system.

5. CARE AND MANAGEMENT OF ORCHARDS

Pruning is rarely practised except with upright varieties such as Pollock. In spreading varieties like Fuerte, branches are thinned and shortened. Heavy pruning has been found to promote excessive vegetative growth, consequently reducing the yield.

Sprinkler irrigation has been reported to improve the fruit size and oil percentage; also, it advances harvesting time. Irrigation at intervals of three to four weeks during the dry months is beneficial to avocado. To avoid moisture stress during winter season, mulching with dry grass/dry leaves is desirable. Flooding is undesirable as it promotes root rot incidence.

Avocados need heavy manuring, and application of nitrogen has been found to be most essential. In general, young avocado trees should receive N, P₂O₅ and K₂O in a proportion of 1:1:1 and older trees in the proportion of 2:1:2. At a pH of above 7, iron deficiency symptoms may appear, which may be corrected by applying iron chelate at the rate of 35 g/tree.

Various micronutrients (Fe, Zn, B) have profound influences on tree growth, nutrient uptake and yield of avocado. Integrated nutrient management with inorganic fertilizer, supplemented by organic manuring, is advocated for avocado.

In Sikkim, the soil is deficient in nitrogen, zinc and boron. Application of urea in two split doses, in March/April and September/October (just before and after the onset of the monsoon) is recommended. Foliar application of zinc sulphate (0.5 per cent) may be undertaken in April-May, and other fertilizers applied in soil during March-April. A tentative fertilizer schedule recommended for Sikkim (Upadhyay and Srivastava, 1996) is shown in Table 2.

Table 2. Fertilizer Schedule for Avocado in Sikkim

Manure/ Fertilizer (kg/tree)	Time of Application	Age of Plants (year)						
		1 st	2 nd	3 rd	4 th	5 th	6 th	7 th & above
Farmyard manure	February/March	-	10	20	30	40	50	60
Urea	March/April	0.10	0.15	0.20	0.25	0.30	0.35	0.40-0.60
	September/October	0.10	0.15	0.20	0.25	0.30	0.35	0.40-0.60
Muriate of potash	March/April	0.10	0.20	0.30	0.40	0.50	0.60	0.70-0.80
Bone-meal	March/April	0.30	0.40	0.50	0.60	0.70	0.80	1.00-1.50

Among insect pests, scales, mealy bugs and mites are the important ones, and may be controlled by suitable insecticides. Fruit spot disease caused by *Colletotrichum gleosporioides* results in shedding of young fruits. Fruits often become deformed. The infection may remain latent in some fruits. Another strain of the same fungus causes leaf spot. Accelerated softening of fruits caused by *Fusarium solani* and *F. sambucinum* has been reported. The Fuerte cultivar is reported to be more susceptible to anthracnose (*Glomerella cingulata* var. minor) and stem-end rot (*Dothiorella aromatica*) from fruit set till harvest. The time of infection has been found to vary with the seasons and is related to rainfall. In addition, Cercospora sport (*Cercospora purpurea*) and scab (*Sphaceloma perseae*) have been found to attack both leaves and fruits also.

The most serious disease of avocado is the root rot caused by *Phytophthora cinnamoni*, leading to death of plant. The disease situation is aggravated by ill drained and waterlogged conditions. Metalaxyl (Ridomil) mixed with soil before planting or applied as a soil drench controls root rot at least for four months after treatment.

6. FRUIT HARVESTING AND YIELDS

Avocado plants raised from seeds start bearing five to six years after planting. Mature fruits of purple varieties change their colour from purple to maroon, whereas fruits of green varieties become greenish-yellow. Fruits are ready for harvest when the colour of seed coat within the fruit changes from yellowish white to dark brown. Mature fruits ripen six to ten days after harvesting. The fruits remain hard as long as they stay on the trees, softening only after harvest.

The yield ranges from about 100 to 500 fruits per tree. In Sikkim, specifically, on average 300-400 fruits can be harvested from 10-15 years old trees.

In Sikkim, fruits of Purple variety are harvested during July, and for Green variety September-October is the usual harvesting time. In Tamil Nadu, July-August is the peak harvest time. The yield performance of avocado, both in tropical southern India and humid sub-tropical northeastern India is highly satisfactory.

7. POST-HARVEST HANDLING, STORAGE AND MARKETING

Avocados do not ripen on the tree, and fruits soften only after they are picked. Fruits need to be picked carefully. They should be harvested at the correct stage of maturity, when they are still hard and have a minimum oil content of 12 per cent.

In India, fruits of 250 to 300 grams in size are preferred. Most popular varieties are Hass, Fuerte and Green. Hard, mature fruits are harvested and allowed to ripen during transport and distribution. Up to 14 days transport time is considered satisfactory, though unripe avocados can be stored for up to four weeks if the temperature is kept between 5.5 and 8°C. Presently, there is no organized marketing system for avocado as the production is small and production areas are scattered.

8. POTENTIAL FOR AVOCADO PRODUCTION DEVELOPMENT

The agro-climatic conditions prevailing in various parts of the country appear to be favourable for bringing more areas under avocado. Presently, plantations are not well organized and they are scattered. Also, quite a good number of improved varieties are now available with higher yield potential. Vegetative propagation techniques have also been standardized. Multiplication of a large number of high-quality nursery plants of selected varieties and their systematic planting, both in tropical southern India and humid semi-tropical areas of the northeastern region of India, could help to place avocado properly on the fruit map of India. The research support for the crop is still very poor, but the available research information from Tamil Nadu and Sikkim amply demonstrate that size, colour and quality of fruits attained in India are comparable with those of avocado fruits grown elsewhere. Avocado is grown successfully in neighbouring Sri Lanka, where good-quality fruits are harvested during May to August and December to January at different regions. Similar agro-climatic conditions to Sri Lanka are available in the Andamans and Nicobar Islands and in the tropical southern India. With proper varietal selection it should be possible to exploit also the possibility of out-of-season production, thus enhancing the availability of fruits for a longer period during the year. Avocado fruits produced in the country can be marketed without much difficulty, particularly to meet the requirement of the growing tourist industry. The mainland India and the Andaman and Nicobar Islands are attracting foreign tourists in a large number of places, where avocado could find a good market access. Avocado has also a good export potential.

9. CONSTRAINTS IN AVOCADO PRODUCTION DEVELOPMENT

One of the important constraints appears to be due to the consumer preference. In the domestic market the avocado may not be liked by the common people due to the nature of its taste and also due to availability of many other tropical fruits throughout the year which are more palatable than avocado. Nevertheless, due to increasing health consciousness among the educated population and the high nutritive value of avocado, it is expected to find its rightful place in the Indian market in due course. The successful introduction of avocado and its wide acceptance among the tribal population of the hilly state of Sikkim indicate that for household nutrition security avocado should be a potential fruit crop in India.

10. GOVERNMENT POLICIES AND PLANS FOR RESEARCH AND DEVELOPMENT OF AVOCADO

Presently, there is no definite governmental plan to strengthen research and development of avocado in India. Research centres in Tamil Nadu and in Karnataka are maintaining some germplasm of avocado in their collections.

11. CONCLUSIONS

Due to the availability of a large number of fruit crops in India and consumer preference for more palatable fruits of sweet taste, avocado has not caught the imagination of the average Indians. With some governmental support it can be popularized in the country and it can provide much needed household nutrition security to the Indian population.

AVOCADO PRODUCTION IN INDONESIA

Sri Setyati Harjadi *

1. INTRODUCTION

The avocado has been spread throughout the Indonesian archipelago since the seventeenth century when it was brought into the country by Spanish merchants. However, its cultivation is seen to be restricted to the mountainous regions, where some tourist resorts are found. Unlike other tropical fruits the avocado is not juicy and sweet and, therefore, is not easy to make the fruit popular among local consumers.

The fruit received wider attention in 1997, when a home garden campaign was launched to highlight its nutritional value. However, its popularity started to increase after the inauguration of 'Es teller 77' food stalls in several big cities by an enterprising entrepreneur. In these food stalls, avocado is prepared together with jackfruit as a fruit cocktail. Good quality avocado is needed for this purpose. Another mode of preparation is a milkshake (which is called avocado juice), where inferior quality fruit can be used, since milk and sugar can be added and blended. Better economic development in the country and rising incomes of the population have given a further impetus to its popularity. Lately, consumption has been increasing further by the popularization of its use as a stomachache medicine as well as due to its high content of the beneficial component of cholesterol.

3. PRESENT SITUATION OF AVOCADO CULTIVATION

Total production in Indonesia is estimated to be 71,001 tonnes from Java (1994) and 46,471 tonnes from the outer islands (1996). It can be seen from Table 1 that the major producing areas in Java island are West Java followed by East Java. The production season is more or less continuous throughout the year, but the peak is October to March. The production areas in West Java are the district Garut (18,285 tonnes), Sukabumi (5,633 tonnes) and Cianjur (4,567 tonnes). In Garut, the season is distributed rather evenly, with production in the four quarters of the year being 3,537, 3,770, 4,123 and 6,856 tonnes respectively, while in Sukabumi the peak season is in the last quarter of the year with a production of 5,138 tonnes. Production in East Java is confined to Ponorogo district (5,405 tonnes), Lumajang (4,500 tonnes) and Sidoarjo (3,630 tonnes). The peak season is mostly in the second half of the year, with the exception of Lumajang which also has a harvest in the first quarter of the year. The main growing district in Central Java is Semarang with a total production of 2,994 tonnes. From the outer islands (Table 2), the major producing provinces are West Sumatra, Jambi, South East Nusa and South Sulawesi with production of 4,615, 3,193, 17,202 and 5,666 tonnes respectively.

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Table 1. Estimated Production in Java in 1992 and 1994 (tonnes)

1992	1 st quarter	2 nd quarter	3 rd quarter	4 th quarter	Total
Jakarta	39	26	20	7	92
West Java	10,757	7,135	6,288	14,033	38,213
Central Java	2,459	368	108	2,191	5,126
Yogyakarta	222	91	37	201	551
East Java	4,865	421	10,966	3,581	19,833
Java Total	18,342	8,041	17,419	20,013	63,815
1994					
Jakarta	20	55	4	24	103
West Java	13,659	6,757	10,607	12,952	43,975
Central Java	1,219	307	346	2,017	3,889
Yogyakarta	258	161	58	235	712
East Java	9,139	3,567	1,215	8,401	22,322
Java Total	24,295	10,847	12,230	23,629	71,001

Table 2. Production in Outer Islands in the Year 1996 (tonnes)

1996	1 st quarter	2 nd quarter	3 rd quarter	4 th quarter	Total
Sumatra	5,980	3,609	3,161	4,995	17,745
Bali & S. Nusa tenggara	9,958	3,704	2,141	3,872	19,675
Kalimantan	129	101	63	81	374
Sulawesi	3,228	1,442	1,239	2,324	8,233
Maluku & Irian	160	105	95	84	444
Total	19,455	8,961	6,699	11,356	46,471

The area under cultivation is not reported, since there are no avocado orchards of any substantial size. The trees are grown mostly in home gardens, without any specific spacing, and often mixed with other fruit trees. Statistics have been computed from the number of harvested trees.

The varieties grown in Indonesia are of two types, which are supposed to have been derived from the West Indian race which has a bigger fruit size. On the other hand, the smaller types have been derived from the Mexican race and its natural hybrids. In general, people differentiate the avocado into two big groups; the butter type (or mentega), the fruits of which are rich in nutrient constituents and have high content of fat and vitamin A, and the milk type (or susu) which has rather thin flesh and low fat content. There are also the 'Ijo panjang' and 'Ijo bundar' types which are long and round, green in skin color with relatively small seeds. From these types there are the 'Tawangmangu', 'Batu' and 'Lembang' varieties. There is also the 'Gontor' type, the fruits of which are medium-sized, round, purple, having rather rough skin.

3. PRODUCTION OF PLANTING MATERIAL

The propagation of avocado is mainly carried out by seed while the use of grafted plants is very limited. This is probably due to the short juvenility of the seedlings, or the preference for taller and bigger trees since they are not grown in monoculture orchards, but mainly in mixed gardens. An important character to be noted is that the seeds from the mentega type exhibit the phenomenon of polyembony during germination. Not many specialized private nurseries are found in Indonesia, especially for production of avocado seedlings. Previously, the Horticulture Research Station had some germplasm collections in Cipanas, but after research priorities changed in favour of short duration crops that could yield quick results, those collections were abandoned.

4. CARE AND MANAGEMENT OF AVOCADO TREES

For the popularization of the concept of 'Home Garden Intensification for Family Nutrition', avocado seedlings are among a number of fruit seedlings to be distributed to farmers to be planted along fences. No special attention is paid after planting nor throughout the lifetime of avocado trees.

Some people believe that if their trees are attacked by caterpillar, they will fruit better than healthy trees. That is why no efforts are made to control the pest. This is also probably due to inter-mixing culture of avocado trees with other fruit trees, so the pest attacks are sporadic. Besides that, protecting the trees through chemical spraying in a home garden is not feasible. However, population explosion of the pest seldom occurs, and elimination is progressively accomplished through nonchemical spraying practices.

In general, no serious pests and diseases are found in avocado trees. Occasionally, a good healthy tree dies suddenly from an attack of root rot caused by *Phytophthora cinnamoni*. Usually, this occurs in areas where cinnamon grows nearby.

5. HARVESTING OF FRUITS AND YIELDS

The harvesting is achieved manually by a picker climbing the tree and taking a basket or jute bag. The fruits are picked selectively by hired laborers or the owner. Only the mature fruits, which show dull appearance, are picked. Some pickers use to shake the fruits to see whether the seeds are not clinging any more, looking for a sign of maturity. The quality of the fruits is determined by the maturity of the fruit. The mature fruits contain more fat and vitamin A.

Sometimes harvesting is carried out by the buyers. When the picking is conducted by the buyers, usually they pick all fruits in the tree whether mature or not. In such cases, the quality of the fruit is poor. However, in the off-season, low quality can be compensated by high price. In general, yields are considered to be good. However, higher yields can be obtained provided appropriate cultural practices are applied by the growers.

6. MARKETING

Simple marketing channels operate from the growing areas to the consumer markets in big cities. The total production can still be absorbed by the domestic market. The retail price is slowly increasing and no fluctuations are seen between seasons. No high volumes are exported, and so is the situation with regard to imports (Table 3).

Table 3. Export and Import of Avocado

	1994	1995	1996	1997
A. Export				
Avocado				
Volume (kg)	1,112	3,210	5,087	1,968
Value (US\$)	1,482	3,999	5,264	359
All fruits				
Volume (tonnes)	40,894	68,923	122,851	83,344
Value (US\$ 1,000)	11,068	16,053	32,019	21,883
B. Import				
Avocado				
Volume (kg)	15,495	18,241	14,484	8,758
Value (US\$)	20,543	24,164	33,063	20,509
All fruits				
Volume (tonnes)	83,791	122,907	139,895	188,495
Value (US\$ 1,000)	66,604	89,898	100,269	100,897

7. POTENTIAL FOR AVOCADO PRODUCTION DEVELOPMENT

The recent increases in production were due to commercial activity for increasing consumption with no government intervention. Any assistance from the government can accelerate the production increases. The produce can be used to improve the diet of the people (the poor as well as the rich). The crop has a wide ecological adaptation and can also be used in reforestation programmes. Good germplasm is already available in the country. Selection, multiplication and distribution of good-quality planting material could be accomplished easily.

8. CONSTRAINTS

The limited knowledge of the farmers in avocado tree husbandry can shorten the lifespan of the trees. Also, the lack of knowledge on post-harvest technology can limit the optimum use of this cheap nutritious food. To make frozen product for baby food or just distribution to the mothercare programmes training and education are needed.

There is a paucity of information and knowledge on the nutrient composition of this fruit. In addition, the role on energy contribution is not recognized by some nutrition specialists. In a 100-gram edible portion 5.8 - 23 grams of fat are found (partly nonsaturated fat that has anticholesterol properties), 75 to 135 international units of vitamin A and 600 to 800 kilojoules of energy.

9. GOVERNMENT POLICIES AND PLANS FOR AVOCADO RESEARCH AND DEVELOPMENT

The Government of Indonesia, through the Ministry of Agriculture, plans to make the country self-reliant in horticulture production by the year 2003. It is hoped that avocado would obtain priority instead of crops like mango and others. This is supported by the fact that the avocado has better food and nutrition value for children under five and lactating mothers.

10. CONCLUSIONS

Indonesia has good potential for avocado production development. By using the traditional home garden as the basic production unit, good progress has been achieved already. Good germplasm already exists in the country and a host of natural hybrids give the breeder the opportunity to select promising material for every agro-ecological region of the country. Selection, multiplication and, finally, distribution of good-quality plants to the farmers need to be done systematically. The education on nutritional attributes of the fruit and the improvement of horticulture practices should be priority areas for development, especially popularizing the production technologies to nontraditional areas in the outer islands of the country.

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AVOCADO PRODUCTION IN MYANMAR

U Aung Soe *

1. INTRODUCTION

Avocado was introduced into Myanmar over 60 years ago and it was first planted at Pyin U Lwin (formerly known as Maymyo), which is a hilly resort with pleasant weather. Pyin U Lwin is situated in the east of Mandalay. Its altitude is 1,165 metres and the average annual rainfall around 1500 millimetres. The minimum temperature is 9°C.

The area of avocado was first expanded to the neighbouring towns of the northern Shan State and later to Southern Shan State; also, to Kayah and Chin States. Geographically, all these states are in the hilly regions which have relatively lower temperatures, with favourable annual rainfall distributed over a period of five months, from mid-May to mid-October. Avocado continues to be cultivated by the farmers as a backyard crop and no commercial plantations exist in the country.

The Myanmar Agriculture Service of the Ministry of Agriculture and Irrigation has planted avocados in three government farms. These are:

- Dokwin Farm, Pyin U Lwin township, Mandalay Division (0.5 ha).
- Pwaytaung Farm, Pyin U Lwin township, Mandalay Division (5.0 ha).
- Lung Pi Farm, Falam township, Chin State (1.0 ha).

2. PRESENT SITUATION OF AVOCADO CULTIVATION

The cultivated area, yield and production of avocado in different parts of Myanmar are shown in Table 1.

Table 1. Area, Yield and Production of Avocado in Myanmar

District	State & Division	Cultivated Area (ha)	Yield (tonnes/ha)	Production (tonnes)
Pyin U Lwin	Mandalay Division	155	8	1,240
Kyaakme	Northern Shan State	115	7	805
Lashio	Northern Shan State	2,110	7	14,770
Taunggyi	Southern Shan State	1,472	8	11,776
Loikaw	Kayah State	223	7	1,561
Falam	Chin State	35	6	210
	Total	4,110		30,362

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The avocado trees grown are all seedlings. Under normal conditions each plant bears 150 to 200 fruits and each fruit weighs about 0.33 kilograms.

The existing scattered trees are classified into three categories, which the local people consider as local varieties. These are: a) Anyo Myo, with dark coppery-coloured fruits; b) A Sein Myo, with round green-coloured fruits; and c) Buthi Pon Myo, with oval-shaped and small neck fruits. Up to the present time, no research work has been carried out on avocado in Myanmar.

3. PROPAGATION

In Myanmar, avocado is propagated by seed, and all raised plants are seedlings. Normally, one-year-old seedlings are planted out in the field. There are no budded/grafted plants as vegetative propagation of avocado is not practised.

4. CARE AND MANAGEMENT OF TREES

The young plants are allowed to grow freely until they reach a height of one-metre. At that time the top of the plant is removed to stimulate the growth of lateral buds. Usually, three to four shoots are left and taken care of to become the main branches of the tree.

Prior to the planting about 10 to 15 kilograms of manure are added to the pit. About 100 grams of 15:15:15 compound fertilizer are applied at planting time. Four months later, the same amount of compound fertilizer is applied. When the seedlings are at the age of 8 to 12 months, 225 grams of the compound fertilizer are applied to each plant. In the second year 500 grams of compound fertilizer are applied twice. However, the compound fertilizer is applied three times in the third and fourth years at the rate of 350 grams per split dose. For the mature trees 10:5:20 compound fertilizer is applied at the rate of 2 kg/tree.

During the rainy season, manual weeding is carried out at 30-day intervals, but the weeding interval is extended to 60 days in the post-monsoon season. Straw or dried leaves are normally used as mulching materials to prevent moisture losses from the soil. The plants are irrigated every 15 days if water is available.

Insects pests are not a serious problem. Sometimes in May and June beetles and caterpillars may appear in some regions, but can be controlled effectively with locally available insecticides.

Major diseases of avocado are anthracnose, downy mildew and powdery mildew. In some specific areas soil-born fungal diseases can be serious. The occurrence of *Phytophthora cinnamomi* has been recorded, but it does not appear to be a serious problem.

5. HARVESTING OF FRUIT AND YIELDS

Avocado fruits mature in about 180 days from the date of fruit setting. Under normal conditions about 150 to 200 fruits are harvested from each tree. In general, the fruits are hand-picked as soon as they are mature.

6. MARKETING

Harvested avocado fruits are packed in bamboo baskets with layers of straw to prevent damage during transport. The baskets are covered with polyethylene sheet. Each basket has a capacity of 70 to 100 fruits. The avocado fruits are marketed locally at present.

7. POTENTIAL FOR AVOCADO PRODUCTION DEVELOPMENT

There are good prospects for avocado production development in the country for two main reasons. One is that the nutritional value of the fruit is very high; it is very rich in vitamins as well as minerals. It is known that because of the dietary habits of the local people vitamin and mineral deficiencies are quite common. Therefore, the development of avocado production will help the local people to improve their nutritional standards. The second reason is that with the development of the hotel and tourist industry there will be an increasing demand for this fruit by the tourists who will be visiting the country, and they already know its value. Therefore, the prospects of marketing locally appear to be good.

8. CONSTRAINTS IN AVOCADO PRODUCTION DEVELOPMENT

At present, there is very little appreciation to this fruit by the local people, probably because they are not aware of its nutritional value. Another obstacle in its development is the unavailability of superior commercial varieties.

9. CONCLUSIONS

It appears that avocado has a good future for development in Myanmar provided that the people are aware of its high nutritional value. For this purpose, superior varieties of quality fruit will have to be made available for the farmers. These varieties should be vegetatively propagated in the nurseries.

AVOCADO PRODUCTION IN THE PHILIPPINES

Rachel C. Sotto *

1. INTRODUCTION

At the end of the nineteenth century, several plant species were introduced into the Philippines. These came from different parts of the world and included fruits, vegetables and medicinal plants. Some proved to be valuable and easily adapted to the Philippine conditions while others were less promising and did not gain a wide acceptance among the populace. One of the introductions which proved to be suitable to the Philippine soil and climatic conditions was the avocado.

Known as 'aguacate' in Spanish and 'alligator pear', 'Palta pear', 'Midshipman's butter' and 'avocado' in English, it is called as 'abokado' in the Philippine vernacular. It was introduced into the Philippines in 1890 by the Spaniards through seeds coming from Mexico. However, it was only from 1902 to 1907 that avocado was introduced successfully into the Philippines by the Americans. Through the Bureau of Agriculture (now the Bureau of Plant Industry which is under the Department of Agriculture), planting materials were received from Hawaii, Costa Rica and the United States. In 1913, the Bureau of Agriculture, together with the College of Agriculture of the University of the Philippines Los Baños, started the countrywide spreading of avocado trees. Now, avocados are found growing all over the country, most of which are cultivated in backyards.

2. PRESENT SITUATION OF AVOCADO CULTIVATION

Crop statistics, compiled by the Bureau of Agricultural Statistics of the Department of Agriculture showed that in 1990-1997 the Philippines had a total area of 4,753 hectares planted with avocado (Table 1). Average annual production was estimated at 45,884 tonnes. Leading producing regions of the country are the Cagayan Valley, Central Visayas, and Southern Tagalog, while the leading producing provinces are Bohol, located in Central Visayas, and Isabela, Nueva Vizcaya, Quirino and Cagayan which are located in the Cagayan Valley. In terms of area planted with avocado, Bicol is the leading region, followed by Cagayan Valley and Southern Luzon. Most regions of the country, however, have low productivity since avocado is grown mostly as a backyard tree or as a component of a mixed orchard with little or no care at all.

In the Philippines, two distinct types of avocado exist, namely the green-fruited and the purple-fruited types. In other countries and notably in the USA, the green-fruited varieties are preferred. In the Philippines, however, the purple-fruited varieties are preferred by the consumers.

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Table 1. Area Planted with Avocado, Number of Bearing Trees, Production and Yield by Region (mean of 1990-1997 figures)

Region	Area (ha)	Number of bearing trees	Production (tonnes)	Yield (t/ha)	Yield (kg/tree)
CAR	246	33,740	1,834	7.5	54
Ilocos	324	41,982	2,237	6.9	53
Cagayan Valley	730	111,263	18,455	25.3	166
Central Luzon	95	10,974	249	2.6	23
Southern Tagalog	691	83,541	2,690	3.9	32
Bicol	762	69,752	1,923	2.5	28
Western Visayas	454	45,821	1,048	2.3	23
Central Visayas	520	49,530	11,899	22.9	240
Eastern Visayas	124	14,757	449	3.6	30
Western Mindanao	178	18,319	744	4.2	41
Northern Mindanao	85	10,683	466	5.5	44
Southern Mindanao	98	13,291	999	10.2	75
Central Mindanao	78	9,055	283	3.6	31
CARAGA	308	26,307	1,116	3.6	42
ARMM	60	6,506	1,492	24.9	229
Total	4,753	545,521	45,884	9.6	84

Source: Bureau of Agricultural Statistics, Department of Agriculture (1998).

The avocado varieties in the country have been developed mainly through introduction and selection. Many varieties have been introduced since 1903 and most of them have been lost. Today, only a few varieties exist. Most of them are selections from local seedling trees, and they are confined to only a few nurseries and backyards. These are:

Cardinal: The fruit bottlenecked with an average weight of 400 grams. The skin is reddish-purple and thick (1.3mm). The seed is small (40 g) and is loose to tight in the cavity. The flesh is yellow, moderately fibrous and constitutes 80 per cent of the whole fruit by weight.

Calma: The fruit ovoid and weighing 600 grams. The skin is reddish-purple and intermediate in thickness (1.0 mm). The seed is small (80 g) and is loose in the cavity. The flesh is yellow and is 80 per cent of the whole fruit by weight.

Uno: The fruit ovoid and weighing 400 grams. The skin is purple and is rather thick (2.0 mm). The seed is small (80 g) and is loose to tight in the cavity. The flesh is creamy yellow and is 80 per cent of the whole fruit by weight.

240: The fruit ovoid and weighing 600 grams. The skin is green and thin (1.26 mm). The seed is intermediate in size (90 g) and is rather loose in the cavity. The flesh is creamy yellow and is 80 per cent of the whole fruit by weight.

227: The fruit is bottlenecked and weighing 500 grams. The skin is purple and thick (1.3 mm). The seed is small (50 g) and is loose in the cavity. The flesh is dark yellow and is 80 per cent of the whole fruit by weight.

Recently, three new varieties were approved by the National Seed Industry Council. However, these have not yet been released to the private nurseries. These new varieties are:

Parker: The fruit ovoid and having an average weight of 600 grams. The skin is purple and thick (1.1 mm). The seed is small in size (70 g) and is tight in the cavity. The flesh is creamy yellow and is 80 per cent of the whole fruit by weight.

RCF Purple: The fruit ovoid and weighing 400 grams. The skin is reddish-purple and thick (1.2 mm). The seed is small (40 g) and is loose in the cavity. The flesh is creamy yellow and is 80 per cent of the whole fruit by weight.

Cepillo Green: The fruit pyriform and weighing 700 grams. The skin is green and intermediate in thickness (0.9 mm). The seed is intermediate in size (90 g). The flesh is dark yellow and is 80 per cent of the whole fruit by weight.

No varieties have so far been identified for rootstock use. Available seeds coming from the season's produce are usually sown and the resulting seedlings are used as rootstocks.

3. PRODUCTION OF PLANTING MATERIALS

Since the avocado is not considered a major fruit in the country and is planted mostly in backyards, only a limited amount of planting material is being produced in a few government institutions and private nurseries. Planting materials may come in the form of grafted plants or seedlings for rootstock use. Government agencies such as the Bureau of Plant Industry of the Department of Agriculture and the University of the Philippines Los Baños, particularly the National Seed Foundation and the Department of Horticulture, produce a few hundred grafted plants of locally available varieties. Small private nurseries which also sell sexually propagated avocado plants are a good source of seedling rootstocks for propagation. Seedlings grown in the nurseries are heterogeneous - each seedling different from another, even though the seeds may have come from one variety or only from one parent tree.

The commonly used and preferred method for large-scale propagation is grafting. This method is less labour-requiring, faster and economical in the use of scion materials. In the case of cleft-grafting, 6-12 months old seedlings are used as rootstocks. Budwood sticks are obtained from the season's mature growth with well-developed terminal buds. New shoots are formed within three to four weeks.

Other methods of propagation which are sometimes employed are inarching and shield-budding. Inarching is a slow and laborious process although it can be used during the rainy season when grafting and budding cannot be done successfully. Shield-budding on the other hand is a fast method. However, it requires skill.

4. ESTABLISHMENT OF ORCHARDS

For orchard planting in flat to gently rolling terrain, the land is cleared, ploughed deeply to break the hard subsurface soil layer and harrowed two or three times to achieve the desired soil tilth and to level the field. For rolling land and steep slopes, ploughing and harrowing are not practised. Instead, hand forking and hoeing are carried out so as to minimize erosion. Stakes are then set, following the desired distance of planting. Depending upon the variety, the plants are set at 8-10 m apart to give a population of 100-156 trees per hectare. Holes which are deep and wide enough to accommodate the root system of the planting material are then dug at the places occupied by the stakes.

Before planting, the leaves of the planting materials are pruned in half to reduce transpiration. After removal from the container, the plants are set in the prepared holes. The holes are then filled up with top soil which is packed firmly around the stem. The plants are then watered immediately after planting.

Planting usually takes place at the onset of the rainy season to minimize the need for frequent watering of the newly set plants in the field. However, in areas where there is a uniform distribution of rainfall or where irrigation water is readily available, planting takes place at any time of the year.

5. CARE AND MANAGEMENT OF ORCHARDS

Training and pruning of plants

Avocado requires very little pruning once the tree has been established. When the trees are still young, especially during the first few years, the plants are trained to a desirable shape by allowing three well-spaced branches to develop and eliminating the rest. Once the trees have attained the desired form, pruning is confined to the removal of diseased, infested and interlacing branches and watersprouts.

Fertilizer application

Many avocado trees in the Philippines are grown without the benefit of fertilizer. This may be the reason why fruit yield and quality tend to decline after fruiting for several years.

Under the existing orchard soil conditions in the country, young and nonbearing avocado trees require only nitrogenous fertilizer. Farmers apply 100-200 grams of ammonium sulphate or about 50-100 grams urea/tree, twice a year. As the trees bear fruit, 500 grams of complete fertilizer are applied, twice a year. For full-bearing trees, two kilograms of complete fertilizer are applied per year. A supplemental application of organic fertilizers, e.g. animal and poultry manure, and compost, is also given.

The fertilizer is applied at the onset and towards the end of the rainy season. It is usually applied in a ring around the trunk of the tree or in shallow holes dug beneath the tree canopy.

Weeding and mulching

Mulching of avocado trees is not practised in the Philippines. Weeding, on the other hand, is confined only to the removal of weeds within a one-metre radius from the trunk especially when the trees are still young; it is usually carried out manually with the use of a scythe or mechanically with the use of a grasscutter.

Irrigation

The practise of irrigating avocado trees in the country is uncommon. The plants are irrigated only when they are newly planted in the field and at certain times of the year when the dry season extends from four to five months. Otherwise, the trees are rainfed. Irrigation is effected manually.

Control of pests and diseases

The insect pests attacking the avocado, in order of their importance, are the following:

Borers: The borers, *Niphonoclea albata* and *Niphonoclea capitoe*, attack the trunk, pith and twigs by boring their way and cutting off the plant's tissues. Lime wash and lime sulphur are used as repellents. In some instances, the tree is sprayed with insecticide.

Scale Insects and Mealy Bugs: The scale insect, *Aspidiotus destructor*, and the mealy bugs suck the sap from the leaves, shoots and fruits, causing premature falling of the fruits. Oil emulsion spray is used in controlling these insects.

Oriental Fruit Fly: The Oriental fruit fly, *Dacus dorsalis*, attacks the mature fruits which are about to ripen. They are controlled by spraying with malathion.

The major diseases which affect the avocado are:

Root rot: This is caused by the fungus *Phytophthora cinnamomi*. Symptoms include yellowing of leaves, sparse foliage, wilting of leaves and dieback of shoots. Prevention of conditions conducive to the growth of the fungus by providing adequate drainage or avoiding planting in waterlogged areas seems to be the best method at present to control the disease.

Anthracnose: This is caused by *Colletotrichum gloeosporioides* and affects the leaves, twigs and fruits. It is controlled by spraying with Bordeaux mixture or copper sulphate.

A minor disease of the avocado is the scab which is caused by *Sphaceloma perseeae*. It attacks the fruit and is controlled by spraying with Bordeaux mixture.

6. HARVESTING OF FRUITS AND YIELDS

Avocado fruits are harvested when they are fully mature. Indications of maturity are the appearance of reddish-purple streaks on the stem-end of purple-fruited varieties and a change in colour from green to light green on green-fruited varieties. In the case of loose-

seeded varieties, an indication of fruit maturity is the production of a hollow sound when the fruit is tapped with the fingers.

Avocado fruits on the same tree do not mature at the same time, so selective harvesting is usually practised. This requires going over the tree several times until all the fruits are harvested. Harvesting is accomplished manually by climbing the tree or by using a ladder. Fruits which cannot be reached by hand are harvested with the use of a long bamboo pole fitted at one end with a wire hook and an attached net to catch the fruits. The fruits are then placed in sacks or in rattan or bamboo baskets lined with banana leaves, for transport to the market.

From the national figures on area and production for the years 1990-1997, a mean annual yield of 9.6 t/ha with 84 kg/tree was estimated. This is quite an improvement from the figures recorded 15 years earlier, when mean yield was only 4.9 t/ha with 50 kg/tree. Though the total area planted and the number of bearing trees recorded for both periods did not change drastically, the yield almost doubled. This was due to the increased yield reported for the Cagayan Valley, Central Visayas and ARMM. The reason for this could only be surmised. This may be due to improved production practices followed by the farmers in these regions. Otherwise, the yield in the other regions did not change much.

In terms of quality, much is to be desired. Most of the avocado fruits sold in the market are of poor quality. This is due to poor crop management employed by the farmers plus the fact that most of the trees grown come from seeds of unknown origin. Another reason for the low quality of the fruits is the poor accessibility of the production areas of the avocado. In many instances, the farm is situated in areas accessible only by trails and paths making transport of the produce difficult and time-consuming. With proper cultivars and improved production and transport facilities, the yield and quality of avocado are projected to improve substantially.

7. MARKETING

In the Philippines, the marketing of avocado involves two very simple systems. In the first system, the farmers bring their harvest to the market together with other farm produce i.e. banana, root crops, chicken, and sell these directly to the consumers. In this way they obtain a higher price for the avocado fruits. In the second system, a middleman, locally called 'comprador', buys all the avocado fruits from the farmers at a lower price and sells them in the market at a higher price. The middleman generally dictates the farm-gate price since he bears the transportation cost. Under the present nature of small-scale and backyard avocado production, where the volume of production is small, the farmer prefers to sell his produce to the middleman. Avocado production is for the local market. There is no export of avocados at present.

8. POTENTIAL FOR AVOCADO PRODUCTION DEVELOPMENT

Avocado has a bright potential for development in the country and there are several reasons for this.

Firstly, the avocado can be found growing all over the country. This is due to the introduction of several varieties belonging to the three different avocado races, giving the crop a wide range of soil and climatic adaptability. At present, most of the trees are grown from seeds, thus a wide variation in plant and fruit characters exists which gives a good opportunity for selection of superior trees.

Secondly, the avocado has a long fruiting season. In the Philippines, the peak of the fruiting season is from May to September, although some trees in certain localities fruit from January to March. Therefore, a survey of existing plantings and backyard trees should be conducted in order to determine their potential range in flowering and fruiting so as to have an extended production season. Also, by planting varieties which bear fruits at different times of the year, it may be possible to have a year-round supply of avocado fruits.

Thirdly, the avocado is one of the most nutritious and versatile fruits in the world. It is the ideal fruit for the diabetic and anaemic people. It can be eaten alone, as a dessert fruit, as ice-cream flavouring, as salad fruit, as sandwich filling, as a dip or as a soup ingredient. The leaves and the seeds have several medicinal uses. If Filipinos are properly educated on the varied uses of the avocado and if they could acquire the taste for the fruit, then the avocado could be very promising for the domestic market. In addition, export markets for the fruit could be developed.

Lastly, the avocado can be propagated vegetatively with ease, and this is a plus factor in its development. In the country, grafting and shield-budding are used for large-scale propagation although it can also be propagated by marcotting and inarching.

9. CONSTRAINTS IN AVOCADO PRODUCTION DEVELOPMENT

In the Philippines, the avocado has not yet attained the popularity enjoyed by other fruits like mango, banana and pineapple. This is due to the following limiting factors and constraints:

Social constraints

In the Philippines, the avocado is mainly used as a dessert fruit. It is often eaten with milk and sugar but never as a component of a vegetable salad as in other countries. This is because the avocado lacks the sweet or subacid flavour present in mango, banana and pineapple to which the Filipino palate has been accustomed. Furthermore, Filipinos are not aware of the varied uses and excellent nutritional value of the fruit. Therefore, advertisements and a strong promotional campaign on the different uses of the avocado should be carried out in order to change the perception and eating habits of Filipinos regarding the avocado.

Supply of certified planting materials

At present, in the Philippines there are three varieties of avocado (Parker, RCF Purple and Cepillo Green) approved by the National Seed Industry Council, a government body with the task to approve crop varieties for registration. In addition, one introduced variety (Cardinal) and five outstanding local varieties (Calma, Uno, 240, 226 and Lopena), which have been selected from seedling trees, are recommended for cultivation. However, these

varieties have not been expanded widely. A major limiting factor to avocado production development in the country is the lack of certified planting material of these good varieties. Reputable fruit nurseries are scarce. Therefore, accreditation of reliable private nursery operators all over the country is needed, so as to increase the availability of high quality planting material at affordable prices.

Lack of varieties with special attributes other than eating quality

The selection of the currently available varieties was based solely on the fruit's eating quality. Varieties with a high oil content are needed for the processing and cosmetic industries. Varieties which are resistant to root rot still have to be identified. Varieties with a long shelf-life still have to be found. Without these varieties, avocado production in the country cannot be developed to a great extent.

Lack of funds for avocado research and development

Despite its income-generating potential, the government has not given to avocado a priority status for research and development. At present, the government has given only six fruit commodities top priority for research and development. These are banana, mango, papaya, pineapple, citrus and durian. The avocado was not even included in the list of minor fruits.

Many production problems of the avocado still need to be investigated. These include aspects of varietal improvement, pests and diseases, nutrition and rootstock-scion relations. Post-harvest handling and processing of the avocado into various products have to be explored. To venture into avocado research, financial assistance from both government and private sectors is direly needed.

Inadequacy of infrastructure facilities

These are insufficient in most rural areas where avocado trees are grown. Many towns are lacking transportation facilities, farm-to-market roads and communications systems. Invariably, the existing road networks are in poor condition. In addition, not enough transportation facilities are available to bring the farm produce to the market.

Lack of adequately trained specialists and extension workers on avocado production

Most of the problems encountered by farmers in the field could be attributed to poor and ineffective transfer of production technologies. There is a need for a more effective extension service. At present, most of the field technicians cannot provide technical assistance to avocado growers since they are assigned to staple crops such as rice and corn. As a result, the level of technical knowledge of the farmers on avocado production is based solely on their own experience.

10. GOVERNMENT POLICIES AND PLANS FOR RESEARCH AND DEVELOPMENT OF AVOCADO

From 1981 up to the present, only five studies have been carried out by state universities and the Bureau of Plant Industry of the Department of Agriculture (Table 2).

Table 2. Research Projects/Studies on Avocado from 1981-1999

Title of Project/Study	Funding/Implementing Agency	Duration
Avocado Rootstocks Resistant to Phytophthora Root Rot in Cell Cultures	USAID-Israel Cooperative Development Research Program/ The Volcani Center, Israel; University of the Philippines Los Baños	1995-1999
Germplasm Collection, Maintenance and Evaluation of Lanzones and Avocado	University of Southern Mindanao	1988-1997
Breeding Selected Crops (Avocado, Citrus, Passion fruit, Rambutan)	University of the Philippines Los Baños	1990 - 1995
Population Density Study on Avocado	Bureau of Plant Industry – Davao National Crop Research and Development Center	1990 - 1994
Screening and Development of Avocado Cultivars for Domestic and Foreign Markets	University of the Philippines Los Baños	1981 - 1990

The very low number of research studies conducted within a span of 18 years amply demonstrates the very low priority accorded to avocado research and development. As of the moment, the government does not have any plans for avocado production development. If ever an interest on any researchable area of avocado production arises then this will have to be taken up at the initiative and at the expense of the core budget of the interested research institution. For the next five years, no funds for avocado research and development have been earmarked by the government since only banana, mango, papaya, pineapple, citrus and durian from the major fruits and lanzones, and rambutan and mangosteen from the minor fruits have been identified as the priority fruits for research and development.

11. CONCLUSIONS

Despite the long list of limitations and constraints to avocado production development, the future of the avocado in the country looks to be bright. A plus factor is the presence of more than half a million bearing trees in the country from which outstanding selections could be made. With appropriate promotion of the avocado as one of the most nutritious fruits in the world, with a wide variety of uses, the market for the avocado would expand. In the future, improved production technology coupled with improved post-harvest and processing technology would facilitate market development of this crop. Though orchards planted with grafted trees of the best varieties are still rare in this country, it cannot be doubted that many orchards will be established in the future, if not for the export trade, at least for the production of high-quality fruit for local consumption.

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AVOCADO PRODUCTION IN SRI LANKA

Moses Dionysius *

1. INTRODUCTION

Avocado is one of the popular fruit crops grown and consumed in Sri Lanka. It is also a commonly grown fruit in home gardens of the wet zone of the country. Due to its excellent adaptability to the climatic conditions of the wet zone, particularly its tolerance to rainfall during flowering, and with less demand for crop husbandry practices and few pest and disease problems, the growers select avocado as a permanent crop in their home gardens.

The first introduction of avocado into Sri Lanka is not well documented, but some evidence suggests that it could have been originally domesticated during the Dutch occupation, over 200 years ago. However, the first recorded introduction was made on 12th May 1927 during the British occupation of the island. From that time until 1940 several varieties including Datton, Puebla, Winslowson, Gottfried, St. Anne and Pollock were introduced from time to time. During the period of these introductions, the agricultural policy of the government was directed only towards promoting plantation crops such as tea, rubber and coconut and the staple rice, as a result of which the production development programmes on fruits, including avocado, received much less attention. Limited research and development, however, continued on many tropical and sub-tropical fruits and several avocado varieties and their hybrids were identified for production in the mid-country wet zone. Varieties of the West Indian and Guatemalan race were recommended for the mid-country and varieties of the Mexican race were popularized in the upper Uva region of Sri Lanka at elevations above 1,200 metres. Many natural hybrids occurred as a result of escapes from cultivation in government nurseries and today a large population of non-descript varieties thrive in village home gardens of the mid-country and up-country wet zones.

In 1986/87, another twenty varieties were introduced under the auspices of the UNDP/FAO Horticulture Project. Currently, these varieties are being tested and grown under different agro-climatic regions. At present, about 95 per cent of the trees are of seedling origin, resulting from open pollination of the previously introduced varieties. Avocados are directly consumed as fresh fruits and are also processed into fruit salad and fruit drinks. There is an ongoing research programme in processing and utilization of avocado at the Food Research Unit of the Department of Agriculture. In the 1980s, the soybean development programme of the Department of Agriculture successfully developed weaning foods (drum dried flakes) incorporating avocado, soybean and other tropical fruits.

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2. PRESENT SITUATION OF AVOCADO CULTIVATION

2.1 Areas of production

Avocado is well-adapted to the wet zone of the low, mid and high country of Sri Lanka. Presently, avocado is successfully grown in the districts of Kegalle, Kandy, Matale and certain areas of Bandarawela and Nuwara Eliya. The other potential areas where avocado could be grown are Gampaha, Colombo and Kurunegala. Apart from the wet zone, avocado is becoming popular in the intermediate zone as a home garden crop. Its yield potential in the intermediate zone is equally as good as in the wet zone. At present, the total acreage under avocado is around 826 hectares. Generally 2-3 trees can be found in most home gardens. It is hard to find any large-scale plantation in Sri Lanka. Currently, an attempt is being made by the plantation sector to grow avocado on a large scale as an alternative to traditional export crops such as tea, rubber and coconut, under a new crop diversification project. The success of this attempt is still in doubt due to marketing problems in the local market as well as finding avenues to penetrate into non-traditional international markets. The Department of Agriculture is the main supplier of quality and certified planting material. Despite these interventions, productivity of the avocado remains low as modern management practices are seldom followed. There is, however, a good potential for the development of the crop as the tourist industry in Sri Lanka is likely to patronize the fruit. Apart from fresh fruit consumption, the nutritive value of the avocado has been universally recognized and several uses have been found to help promote its utilization. Present yields are low and the recorded annual production is around 11,600 tonnes.

2.2 Varieties

Though several varieties were introduced from time to time in the past, due to lack of priorities for research and development programmes, these varieties were neglected and almost lost. But the expansion of this crop continued mostly through seeds, which were derived from open pollinated trees. As a result, few identified varieties were available for dissemination. The real breakthrough came with the introduction of several varieties in 1986/87 by FAO, since the establishment of a separate Division of Horticulture. As a result of long-term evaluation studies with these varieties, four varieties, namely Fuerte, Booth 7, Simmonds and Tower II were recommended and released by the Variety Release Committee of the Department of Agriculture in 1995. Prior to these introductions, West Indian varieties such as Pollock, Gottfried, St. Anne and the locally developed Purple hybrid were released from Government nurseries for production in the wet zone of the island.

2.3 Rootstocks

Generally, locally collected seeds are used to raise seedlings as rootstocks. No specific varieties have been identified or selected as rootstocks. Fresh large seeds are preferred over small seeds to raise seedlings for grafting. One of the production constraints in the humid tropics is the severe incidence of *Phytophthora* root rot. Bearing trees are often found to succumb to the disease, especially if soil moisture levels exceed required limits. Selected resistant rootstocks are needed to be introduced for adaptability studies.

3. PRODUCTION OF PLANTING MATERIAL

Production of planting material is handled by the Seed and Planting Materials Division of the Department of Agriculture and registered private nurseries. These nurseries currently produce grafted plants of Pollock, Purple Hybrid and other locally selected types as well as recently recommended varieties. The major role of production of grafted plants of the new varieties is undertaken by the Horticultural Research and Development Institute. The plant nursery of this institute has so far produced and distributed nearly 8,000 grafted plants of these new varieties to the Central, Subaragamuwa and Southern provinces, both to small farmers and large-scale growers. In addition, these grafted plants were distributed to government and registered private nurseries to establish budwood gardens for future development programmes on the crop.

3.1 Methods of propagation

Wedge or cleft grafting is the most common method of propagation adapted by nurserymen, due to its high percentage of success. Stocks are wedge-grafted at the age of 4-6 weeks. Since avocados exhibit the phenomenon of polyembryony, the more vigorous nucellar seedlings are usually chosen to raise grafted plants. Rootstock seeds are either sown in seed beds or directly planted in black polythene bags of suitable size. Overgrown rootstocks can also be used for budding during the active growth period of seedlings, often indicated by a vigorous growth flush.

3.2 Top-working

In addition to the production of grafted plants, a 'top-working' programme on seedling trees was successfully carried out by the Horticultural Research and Development Institute in two districts in order to popularize the new varieties. As there is some limitation in finding new lands for the expansion of avocado, this method is considered a practical way of promoting avocado cultivation. This programme is now being handled by the provincial extension services.

4. ESTABLISHMENT OF ORCHARDS

4.1 Land preparation

As a part of land preparation, growers only weed and remove other surface vegetation. As most of the land is undulating, small and large scale growers are advised to follow contour planting and to adopt soil conservation methods. Avocado plantations are seldom established on flat land as the mid-country is usually hilly and undulating. Since the crop is gradually spreading to the low-country wet zone as well, many avocado orchards are being established on somewhat level terrain. In these situations, avocado is inter-cropped with other perennial crops such as coconut, banana, jackfruit, rambutan, mangosteen, etc.

4.2 Planting season

The planting season is based on the rainfall pattern of the area. There are two planting seasons in the wet zone, namely Yala (from June to August) and Maha (from October to December). But the major planting is carried out during Yala, as it follows a

short dry period with intermittent rains, rather than during the long dry period after the Maha season. Under supplementary irrigation, however, avocados can be easily established at any time of the year. Some amount of shading is necessary during the period of planting to provide the necessary growing environment to young plants.

4.3 Spacing

Earlier recommended spacing of 11.5 x 11.5 metres has now been reduced to 8 x 8 metres as new grafted varieties need much less spacing. In fact, new dwarfing rootstocks have now been developed in California, Florida and Israel that require even less spacing. This gives an advantage of increasing the plant density from 100 plants/ha to 170-180 plants/ha and even more. Planting density also depends on the orchard layout. Conventional systems for avocados grown on flat land include the rectangular, square, triangular, quincunx, and the avenue planting systems. On sloping land, it is recommended that orchards be established on the contour planting system where competition between trees is minimized.

4.4 Opening of pits and planting

The size of the planting hole is generally 60 x 60 x 60 centimetres. The holes are filled with equal parts of topsoil and compost. As most of the wet zone soils are acidic, pH adjustment (to 5.5 - 6.5) is achieved by applying Kiesarite or dolomite, according to the recommendations of the Department of Agriculture. At the time of planting, or 2-3 weeks after planting, 450 grams of fertilizer mixture are applied per hole. Grafted plants are placed in planting holes with the graft union kept about 30 centimetres above ground level. Plants are staked to prevent breakage from winds and are kept tied until the tree is firmly established.

5. MANAGEMENT OF ORCHARDS

5.1 Training and pruning

Training and pruning is not an adopted practice in home gardens. In large-scale cultivations, however, training and pruning are adopted, as they give closer spacing (8 x 8 m) to allow maximum coverage of land. As a first step in pruning, the main stem is cut back at a height of 60 cm from the ground, to encourage formation of lateral branches. A maximum of 3-4 healthy lateral branches are allowed around the trunk and the rest are removed. Up to flowering (3-4 years), the basic framework is developed with a modified central leader system. After bearing commences, no pruning is effected. In case of excess vegetative growth, however, a mild pruning is carried out just after harvesting. In addition, all weak branches and diseased shoots are removed annually.

5.2 Application of manures and fertilizers

Two applications of NPK (N:P₂O₅:K₂O - 12:14:14) is the general practice in large-scale cultivation. These are applied at the onset of the southwestern Yala and northeastern (Maha) rains. The amount increases with the age of plants, starting from 0.5 kg/year in the first year and increasing up to 3 kg/year. After bearing commences, 3 kg/year is the recommended amount per tree. Though compost is recommended in addition to NPK, large-scale growers seldom adopt this practice. In contrast to large-scale cultivation, application of

compost and cattle manure is the well-adopted practice in home gardens, where application of NPK is not usually carried out.

5.3 Weeding and mulching

As the avocado is a surface feeder, clean weeding is not recommended as any damage to the root system can accelerate *Phytophthora* infection. Generally, farmers perform weed control by slashing and using the weeds for mulching. Chemical control is not in practice in most avocado orchards. Since weeds contribute to the spread of diseases and pests, orchards have to be kept relatively weed-free. When weeds are slashed and removed, they are used as a mulch which helps moisture retention during the dry season. In large-scale cultivation, *Peuraria* is grown as a green mulch to control weeds. Generally, in home gardens, mulching is not practised.

5.4 Supplementary irrigation

Like most of the other perennial fruit crops, avocado is grown as a rainfed crop. As a result of this, avocado undergoes two major water stress periods, during January to April and July to September, usually causing high flower and fruitlet drop during January to April, and heavy fruit drop during July to September. Any means of providing supplementary irrigation to the crop could easily minimize flower and fruit drop during these dry spells. Usually, in home gardens, growers resort to hand watering during these periods of stress. Most orchards minimize water loss by using live or dead mulches.

5.5 Control of pest and diseases

So far, there have been no major outbreaks of diseases recorded in Sri Lanka. *Phytophthora* root rot, scab and canker are the main diseases that affect avocado. As far as the post-harvest diseases are concerned, anthracnose and stem-end rot are the most common.

Fruit fly and shot hole borer are the major pests in Sri Lanka. Control of fruit fly can be achieved by use of pheromone traps immediately after fruit-set. As avocado is mainly a home-garden crop, and fetches very low prices in the local markets, chemical control measures are not adopted by the growers.

6. HARVESTING OF FRUITS AND YIELDS

Although maturity indices have been developed to detect the correct stage of maturity, traders use only the size of the fruit as an index. During the early season, fruits are often harvested premature and during the harvesting season fruits often become over-mature. Pre-mature harvesting results in poor quality fruits with very high post-harvest losses. Similarly, delayed harvesting results in very high post-harvest losses due to incidence of some diseases that attack the fruit after harvest. Fruits are harvested using a picking-pole attaching a net bag to prevent falling of fruits during harvesting. It is a common practice among traders to remove the stalk attached to the fruit before sending fruits to the market. This operation leads to mechanical damage at the stem end which predisposes the fruit to pathogenic stem-end rot development. The major cause for post-harvest losses of avocado is stem-end rot, which increases the price gap between consumer and grower.

Polysacks are used to pack and transport avocados, which causes considerable mechanical damage as these injuries serve as entry points for the microorganisms causing fruit rot. Artificial ripening is not yet practised among traders. However, keeping fruits at the collection points accelerates the ripening process due to heat buildup and ethylene liberated from other ripening fruits.

7. MARKETING

There is no form of organized marketing system available for avocado. As a general practice, fruit collectors purchase fruits from home gardens and supply produce to the wholesale dealers or to the retail dealers and outlets directly. Since the quality of marketed fruits cannot be assured, consumers are at the mercy of retailers who often sell sub-standard fruits. Under these circumstances, quality control and proper grading cannot be assured. As far as exports are concerned, quantities exported (nearly 2,400-2,600 kg in 1997) are insignificant. Rough handling and bad packaging during transport increases post-harvest losses considerably.

8. POTENTIAL FOR AVOCADO PRODUCTION DEVELOPMENT

There are two major factors that show good potential for avocado production development in Sri Lanka. It is possible to grow many of the tropical and sub-tropical types in several agro-climatic regions of the country. Moreover, in Sri Lanka, the avocado tree grows and produces crops with very little attention and management. In fact, hardly any grower uses harmful pesticides or other agro-chemicals. If at all, only large orchards would use even chemical fertilizer.

8.1 Long production seasons

As the flowering period extends from late November to June in different districts, the production seasons extend from late May to March. The peak production period falls between May and August and the low production period falls between September and March. Current studies of 'on tree storage' have shown that the off-season period of April to May could also be overcome. Therefore, year-round production will be possible in future. This gives an opportunity to improve the export potential considerably. The Mexican varieties and their hybrids perform well in the semi-dry highlands of the island, and for an export industry, this ecological niche could be exploited easily, especially if the tea-estate sector makes a move to commercial avocado production. The large fruits of the West Indian varieties are generally unsuitable for the export market but are much preferred by local consumers.

8.2 Crop diversification in the estate sector

Due to high price fluctuation of tea, rubber, coconut and spices in the international markets, the estate sector faces serious financial difficulties in managing their estates profitably. As an alternative, they are now looking for other crops for diversification. Areas where rubber, spices and tea are grown, provide suitable climatic conditions to grow avocado. As these estates manage large acreage, they can be utilized effectively to grow avocado on a commercial scale for possible export.

9. CONSTRAINTS IN AVOCADO PRODUCTION DEVELOPMENT

The major constraints to avocado development are the following:

- Poor marketing, handling, grading and packing
- Low prices
- Poor quality fruit and low yield
- High harvesting losses due to premature harvesting and unsatisfactory harvesting techniques
- Poor facilities for exporters
- Lack of institutional support for pre-export quarantine

The Horticultural Research and Development Institute of the Department of Agriculture has developed improved production packages and introduced new technologies for avocado, but these are seldom adopted by the farmers. However, even with the current marketing system and poor prices there is a considerable number of growers earning a good income from home gardens and small avocado orchards. Though new varieties were released and recommended in 1995, due to lack of a good extension system for fruit crops, these are still not very popular among growers. Also, there is very little contribution from the Export Development Board of Sri Lanka in promoting the export of avocado.

The knowledge of the average consumer with regard to the nutritional value of avocado is still very poor. Until recently, the avocado was consumed with caution as the level of fat in fruits created some kind of misconception among the people that it was unhealthy to consume. However, with the propaganda launched by the Horticulture Research and Development Institute regarding its nutritional value and its ability to control heart diseases a better awareness was created among people. But it is still a matter of conjecture whether this nutritional information on the food value of the avocado has played a role in increasing per capita consumption.

10. GOVERNMENT POLICIES AND PLANS FOR RESEARCH AND DEVELOPMENT

To overcome the major constraints and to increase productivity, several steps have been taken under the new crop productivity programme launched by the Ministry of Agriculture. Under this programme, it is envisaged to increase the present acreage of 826 hectares to 1,930 by the year 2005. Though the present yields are as low as 14 t/ha, they could be projected to increase by the application of new production technologies to 18-20 t/ha by the year 2005. Thus, the present annual production of 1,154 tonnes is estimated to increase around 33,000 tonnes. Since the average consumer is familiar with this exotic fruit, consumption among the local population is expected to increase in the future.

To achieve this target, the ongoing research programmes on performance of exotic varieties, development of phenological models for different agro-climatic regions, canopy management, improved agronomic packages, application of pest and disease control measures, development of post-harvest technology and new avenues for utilization of the fruit and its oil for the cosmetic industry, will be intensified.

Production of planting material of new varieties will be further expanded to meet the total target of 300,000 grafted plants. The ongoing 'top working' programme will be further popularized and intensified in areas where farmers currently depend on seedling trees.

11. CONCLUSIONS

With the successful implementation of the 'crop productivity enhancement programme' it should be possible to overcome the major constraints, so as to achieve year-round production of high quality fruits in the future. This will give an opportunity to meet the local as well as the export market demand, thereby increasing the avocado farmers' income as well.

The consumers in Sri Lanka have become accustomed to avocado consumption over a long period of time. This positive fact is expected to underpin an increase in area and production during the next few years, using the newly recommended varieties. These varieties can be grown in upcountry Sri Lanka, where large commercial plantations are expected to be established by tea estates, in order also to promote export of fruits to the regional markets of Singapore, Hongkong and Japan.

AVOCADO PRODUCTION IN THAILAND

Chalongchai Babpraserth and Suranant Subhadrabandhu *

1. INTRODUCTION

Avocado (*Persea americana* Miller) is an indigenous plant of South America. It is widely grown in Mexico, Guatemala and the islands of the West Indies (Whiley, 1991). In Thailand, avocado plants were introduced by missionaries and were planted initially in Nan province in northern Thailand about 90 years ago. Some seedlings from these introductions are currently found around this area. In 1965, the Department of Horticulture, Kasetsart University, introduced some avocado cultivars which included Kanoe, Ruehle, Kampong and Monk and planted them at Pak Chong Research Station, Nakhon Ratchasima province. Some avocado cultivars were also introduced by interested growers. In 1975, the Department of Horticulture, Kasetsart University, with support from the World Bank introduced 11 cultivars of avocado from Florida, USA, and established them at Pak Chong Research Station. The introduced cultivars were Buccanaer, Booth 7, Booth 8, Catalina, Choquette, Hall, Lula, Peterson, Queen, Taylor and Waldin. The Hass, Bacon and Reed cultivars were introduced also from California in 1993.

The purpose of introducing avocado cultivars into Thailand was to evaluate their suitability under local conditions. Due to their high nutritive value and wide utilization possibilities, avocado fruits are becoming more popular in Thailand. Apart from being consumed as fresh fruits for their palatability, food value with high protein, vitamin E and digestible fat content, their oil is used also in the cosmetic industry.

2. PRESENT STATUS OF AVOCADO CULTIVATION

The production and planted area of avocado in Thailand increases every year. At present, avocado trees are found planted in Nakhon Ratchasima, Chaiyaphum, Nan, Tak, Chiang Mai, Chiang Rai, Rayong, Chanthaburi and Songkhla provinces. However, the big concentration is in the northern and northeastern regions. Total production area in 1998 was 200 hectares in the north, 50 hectares in the northeast, 5 hectares in the east and 5 hectares in the south with a production of 200, 100, 23 and 20 tonnes respectively.

Due to the unavailability of sufficient quantities of planting material, many growers in the Royal Project Foundation areas of northern Thailand have raised avocado from seedlings. These avocado trees have produced fruits of poor quality. The Kasetsart University personnel who voluntarily work for the Royal Project Foundation tried to persuade growers to graft or bud these avocado seedling trees with the recommended cultivars such as Buccanaer, Hass, Peterson, Booth 7 and Ruehle.

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About 84 hectares of avocado were planted by hill tribe growers under the extension programme of the Royal Project Foundation with a total production of 45 tonnes in 1997. The future planting area of avocado in the five-year plan of the Royal Project Foundation, from 1998-2003, will be 270 hectares with an estimated production of 1,500 tonnes by the year 2005.

Work for better cultivars continues at Pak Chong Research Station. At present, scions from the recommended cultivars are used for grafting, budding or inarching on Guatemalan and West Indian rootstocks (Pak Chong 6-5 and Pak Chong 1-14). Some selected rootstocks at Tung-roeng Development Centre are also used in some growing areas.

3. PRODUCTION OF PLANTING MATERIAL

The Pak Chong Research Station and the Royal Project Foundation are the two main production sources of grafted and budded avocado plants. These two institutions produce more than 4,000 plants per year for the growers.

Seedlings are raised in the nursery under 50% shade. The seeds are cleaned and soaked in fungicide solution for about 20 minutes. They are germinated in 8 x 15 cm PVC bags. The seedlings can be budded or grafted after 4-6 months.

Patch budding or modified chip budding are commonly used depending on the rootstock. If the bark cannot be peeled easily from the stem of the rootstock, modified chip budding must be used. Patch-budding can be used when the bark can be peeled off easily.

Bark-grafting is used when the bark could be peeled off easily from the stem, and this is commonly seen when the rootstock is over six months old. Modified side-veneer-grafting is used for the rootstock that cannot peel off the bark easily, usually when the rootstock is 4-6 months old. Modified side-veneer-inarching is also used for rootstocks that are 4-6 months old.

4. ESTABLISHMENT OF ORCHARDS

4.1 Land preparation

Where hardpan is evident, a sub-soiler is used for breaking the hardpan. The land is ploughed and holes of 60 x 60 x 60 cm are dug. The planting medium is a mixture of soil, animal manure and organic matter at the ratio of 2:1:1. Generally, land preparation is carried out before the rainy season.

4.2 Spacing

Spacing of avocado is dependent on the cultivars and the soil conditions of each site. In Thailand, a spacing of 8 x 6 metres is used for Ruehle, Peterson, Hass and Buccanaer, whereas wider spacings of 8 x 8 metres, 8 x 10 metres, and 10 x 10 metres are used for Booth 7, Booth 8 and Hall cultivars.

4.3 Planting

Planting is carried out at the beginning of the rainy season (May-June). The plants should have no sign of insect pests and diseases on the stems and leaves and they should be subjected to hardening under full sunlight before transferring to the field. The plants are brought to the prepared holes and are removed from bags or containers. They are then placed in the hole, with soil mixture filled and firmed to ensure good contact with roots. They are then watered regularly to ensure availability of sufficient moisture until establishment. Insecticides are sometimes applied to protect from termite damage every three months and also fungicide, often by using 100 grams of metalexyl (Ridomil 50 g) granules around each plant. The plants are protected from wind by planting windbreak trees as well as by using bamboo stakes for supporting newly planted trees.

4.4 Mulching

Plastic sheets can be used as mulching material but this is not seen commonly in Thailand. Often, organic materials such as straw, rice husk and wood chips are commonly used as mulching material because these materials can later decay and become available to plants as organic fertilizer.

5. CARE AND MANAGEMENT OF ORCHARDS

5.1 Training and pruning

Avocado trees are normally trained under a modified leader or open centre system. When plant height of newly established plants is about 70 cm, the growing tips are pinched off to allow development of more side shoots to form a round-shaped tree. After harvesting, the trees should be pruned. The upright branches, water sprouts, dead wood, infected branches, and the branches that are not exposed to the sun should be pruned off.

5.2 Fertilizer application

A mixed fertilizer of 46-0-0 and 15-15-15 at 250 grams/tree is applied two months after planting and the same rate is repeated again three months later. The same formula with a slightly higher rate of 300 grams/tree is applied in the second year at the beginning of the rainy season with repeated applications every three months. From the third year onwards, as well as for bearing trees, the amount of applied fertilizer depends on the radius of the tree canopy, i.e. at every one-meter radius, one kilogram of mixed fertilizer of 46-0-0 and 15-15-15 is applied.

5.3 Weeding

The weeds are often cut, as ploughing to control weeds is not recommended because of the shallow root system of the trees. Some growers use contact or systemic herbicides for chemical weed control.

5.4 Mulching

In Thailand, where the climate is very warm, organic materials are rapidly decayed, so more organic mulching materials are recommended to be applied to the trees.

5.5 Irrigation

Supplementary irrigation during the dry periods appears to be needed for young as well as mature avocado trees.

5.6 Diseases

Avocado root rot is the most serious disease that affects avocado trees in Thailand. The disease is caused by the fungus *Phytophthora cinnamomi*. This soil borne disease is commonly found in acid soils with poor drainage. It is recommended to use resistant rootstocks such as Duke-7 in the areas where the disease is prevalent. A well-drained soil is needed to prevent the spread of the disease. No ploughing underneath the tree canopy is advised. For avocado seedlings in the nursery, 20 ppm Dexon, applied as soil drench, is recommended to control *Phytophthora* in the nursery.

Other diseases that have been recorded are anthracnose on leaves and fruits which is controlled by spraying with mancozeb or carbendazim fungicides. Algal spot was found on leaves also, and can be controlled effectively by spraying with copper oxychloride or, alternatively, by pruning the trees to provide good ventilation.

5.7 Insect pests

The insects that are occasionally found to cause some damage in avocado are termites, twig-cutting bee, leaf-eating caterpillar, thrips and hemiptera species. Usually, the damage from these insects is not up to economic injury levels. In case of serious damage, however, spraying with insecticides such as Sevin can give satisfactory control.

6. HARVESTING AND YIELD

The harvesting time of avocado cultivars in Thailand extends from July to December. Harvesting time of the same cultivar grown under different climatic conditions may vary from one to three weeks. The fruit characteristics of some avocado cultivars are shown in Table 1.

Table 1. Fruit Characteristics of Some Avocado Cultivars in Thailand

Cultivars	Flower type	Shape	Weight gm	Skin Surface	% Fat	Pulp Colour	Taste
Buccanaer	B	pear	250-300	rough	12-18	yellow	excellent
Booth 7	B	round	300-400	green, nearly smooth	12	dark yellow	good
Booth 8	B	pear	300-400	green, nearly smooth	6-12	bright yellow	good
Fuerte	B	pear	150-250	green, smooth	18	yellow	excellent
Hass	A	oval	150-250	rough, black	18-25	yellow	excellent
Peterson	A	round	200-350	smooth	12	dark yellow	good
Ruehle	B	pear	200-350	smooth	10	yellow	good

6.1 Maturity index for avocado in Thailand

a) Skin colour change

Variety

Peterson from green to greenish yellow.
 Ruehle from green to greenish yellow.
 Hass from green to black
 Booth 7 skin colour is still green at maturity
 Booth 8 but stalk colour changes from
 Buccanaer green to yellow

b) Age from fruit-set to maturity

Ruehle 4.5 months
 Peterson 6 months
 Booth 7 8-9 months
 Buccanaer 8-9 months

c) Percentage of fat

As the fruit approaches maturity, the percentage of fat in the pulp increases to reach the standard level, characteristic of each cultivar.

d) Seed coat peels off easily.

e) Percentage of dry matter of the fruit comes to a constant level.

6.2 Yield

The yields of avocado per tree recorded at Pak Chong Research Station are indicated in Table 2. Due to the productivity and eating quality of their fruits, Booth7 and Buccanaer are the two cultivars that have been recommended to growers in Thailand. However, the fruits of the Buccanaer cultivar were found to be of better quality and receive good market acceptance.

Table 2. Avocado Yields per Tree at Pak Chong Research Station

Cultivar	5-year old trees		8-year old trees	
	No. of fruits/tree	kg/tree	No. of fruits/tree	kg/tree
Pak Chong 3-3	110	40.2	209	75.2
Booth 7	249	87.1	527	179.2
Booth 8	200	63.0	280	86.8
Buccanaer	250	70.0	332	146.2
Catalina	117	44.0	182	67.7
Choquette	102	45.9	194	85.5
Hall	225	108.0	380	170.7
Lula	50	17.5	150	52.0
Peterson	110	27.5	150	40.5
Queen	141	51.0	210	73.5

7. MARKETING

Avocado production in Thailand is still small and all fruits are sold locally as there is still high demand in the domestic market. There is, however, a potential for exporting avocado fruits to Japan, Hong Kong and Singapore. Local consumption of avocado fruits is increasing every year, but local consumers should be taught how to eat fresh avocado. Avocado oil extraction for the cosmetic industry is also increasing and there should be a good possibility for establishing a small factory locally when the fruit supply exceeds the local demand.

8. FUTURE PROSPECTS

The results of studies on avocado indicate that this fruit tree is suitable for the northern and northeastern regions of Thailand. At present, extension work is mainly carried out by the Royal Project Foundation and the Department of Agricultural Extension. It is expected that in the next five-year period the area under avocado will be increased to 500 hectares with a projected production of 2,500 tonnes by the year 2003.

The development of the avocado industry in Thailand can be promoted by forming an avocado society. This society should be supported by government institutions like the Ministry of Agriculture and other educational institutes that will help to improve technologies for better management of the crop through research and development. The society should have the bargaining power in selling and exporting fruits. At present, the

Royal Project Foundation helps avocado growers by collecting the fruits from them and selling them to supermarkets and hotels in the cities of Bangkok and Chiang Mai. This marketing system of the Royal Project is only on a small scale and is responsible for growers in the project area in northern Thailand. Therefore, there is a need for another organization to undertake the marketing of avocado for the whole country if avocado production is going to be expanded to other parts of the country.

One important factor to be borne in mind is that the local market for avocado is somewhat slow in expanding as the taste of avocado fruits is not so sweet as compared to other exotic tropical fruits. If the planted area is rapidly increased the price at the farm gate is bound to drop. There is a need to promote the avocado fruit based on its nutritional attributes, especially to make consumers aware of its high nutritional value.

8.1 Future research

The following research studies need to be undertaken in Thailand:

- a) Cultivar selection and breeding for better fruit quality and yield.
- b) Selection of dwarf rootstocks for developing compact trees.
- c) Selection of better rootstocks resistant to Phytophthora disease.
- d) Studies on harvesting and post-harvest handling of avocado fruits.
- e) Study on export market feasibility of avocado fruits to Japan, Hong Kong etc.

8.2 Future production development

The following activities are planned to be carried out in the Royal Project Foundation area:

- a) Top-working of commercial cultivars on existing seedling trees grown by private growers.
- b) Short training of growers and extension staff on avocado production.

9. CONCLUSIONS

Although avocado has been grown in Thailand for almost 90 years, the rate of increase in planting area is very slow when compared to other tropical fruit trees. There are some salient reasons for this situation. Firstly, the people do not understand much about commercial marketing of avocado. The early introduced cultivars gave fruits which were too big and unsuitable for the local and export market. This took a long time to be understood by local specialists. It is only now that better commercial cultivars are being introduced and top-working of the existing trees has been undertaken. Secondly, the taste of avocado fruit is not familiar to local consumers, as they are familiar only with sweet-tasting fruits. The promotion on how to eat avocado fruits must be initiated in Thailand if it is to be incorporated as a component in the local diet.

In the next five-year plan, Thailand will have more area under avocado and, hopefully, avocado fruits will be more and more utilized at home level when consumers realize its high nutritive value. Also, the avocado has some export potential in selected

Asian markets if the appropriate small-fruited types are promoted for cultivation in the cooler northern and northeastern regions of the country.

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AVOCADO PRODUCTION IN VIETNAM

Nguyen Minh Chau & Vo The Truyen *

1. INTRODUCTION

The avocado (*Persea americana* Miller) was first introduced into the Lam Dong province of Vietnam in 1940 by the French. The first introduction was reported to have been greatly successful since trees performed well and gave high yields. During the 1960s some avocado varieties given by the Philippines government were tested in some provinces in the Central Highlands around Blao, Hung Loc and Buon Ma Thuoc. About 93 different exotic varieties were listed at that time and it was also said that avocado growers gained good income due to high demand from consumers, mostly foreigners living in the country at that time (Quyen N.H., 1967).

At present about 400,000 hectares are under fruit cultivation in Vietnam, and it is expected to expand up to one million hectares by 2010 (Chau N.M., 1998). Nowadays, avocados are widely grown in Vietnam including the provinces of Dong Nai, Ba Ria-Vung Tau, Lam Dong, Dac Lac and Phu Tho. A four-year national project to improve the fruit industry in Vietnam has been launched for seven important fruits crops which include avocado. The project is being executed by the Southern Fruit Research Institute (SOFRI), in collaboration with various government horticultural research institutes and universities, under the national research network.

2. PRESENT SITUATION OF AVOCADO CULTIVATION

Although no statistical figures are available on the area and production of avocado, the tree is widely grown in the upland parts of the country i.e. in the provinces of Dong Nai, Ba Ria-Vung Tau, Lam Dong and Dac Lac in the south, and Phu Tho in the north of Vietnam. Twenty-eight different varieties are now maintained by horticultural institutions in these areas (Table 1). Well-distributed in private farms, their original names have been lost, so they are called by various local names given to them according to their fruit shape and quality. The commonest propagation method is by seed. The six varieties which are preferred by Vietnamese consumers are presented in Table 2. To improve the situation, SOFRI introduced recently the Hass variety from Australia into the south, and Hass, Reed, Ettinger and Sharwil into the north of Vietnam.

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Table 1. Avocado Varieties Recorded in Southeastern Provinces of Vietnam (SOFRI, 1998)

No.	Variety Name	Popularity	Distribution
1	Sap qua dai vo xanh	+++	Dong Nai, Lam Dong, Ba Ria-Vung Tau
2	Sap qua dai vo tim	+++	Dong Nai, Lam Dong, Ba Ria-Vung Tau
3	Sap qua tron vo xanh	+++	Dong Nai, Lam Dong, Ba Ria-Vung Tau
4	Sap qua tron vo tim	+	Dong Nai, Lam Dong, Ba Ria-Vung Tau
5	Sap da san vo xanh	+	Dong Nai, Lam Dong, Ba Ria-Vung Tau
6	Sap da san vo tim	+	Dong Nai, Lam Dong, Ba Ria-Vung Tau
7	Sap da lang	+	Dong Nai, Lam Dong, Ba Ria-Vung Tau
8	Sap hat nho	+	Lam Dong
9	Sap vo vang	+	Lam Dong
10	Bo tim	+	Lam Dong
11	Bo bong	+	Dong Nai
12	Bo day	+	Dong Nai
13	Bo oi	+	Lam Dong
14	Bo khoai	+	Lam Dong
15	Bo xanh	+	Dong Nai
16	Bo nep vo xanh	+	Dong Nai, Ba Ria-Vung Tau
17	Bo nep vo tim	+	Dong Nai
18	19*	+	Dong Nai
19	21*	+	Dong Nai
20	23*	+	Dong Nai
21	26*	+	Dong Nai
22	27*	+	Dong Nai
23	28*	+	Dong Nai
24	29*	+	Dong Nai
25	31*	+	Dong Nai
26	35*	+	Dong Nai
27	Bo nuoc qua tron	+	Dong Nai, Lam Dong
28	Bo nuoc qua dai	+	Dong Nai, Lam Dong

+++ more popular

* Collected and maintained by Hung Loc Agriculture Research Center

Table 2. Promising Local Varieties

No.	Variety Name	Given Codes	Location
1	Bo sap qua dai	BSLD1	Lam Dong
2	Bo sap qua dai	BSDN3	Dong Nai
3	Bo sap qua dai	BSBRVT5	Ba Ria-Vung Tau
4	Bo sap qua tron	BSDN2	Dong Nai
5	Bo nep	BNDN4	Dong Nai
6	Bo bong	BBLD6	Lam Dong

Source: SOFRI, 1998

Though avocado was introduced into the country a long time ago, its production is still small compared to other tropical fruits such as mango, longan, rambutan and durian, due to various reasons. At present, the avocado is not grown in monoculture and it is rarely found grown under intensive care on an orchard scale. It is observed to be used increasingly as an intercrop or as a shade tree for coffee, other than in mixed culture in fruit plantations, or as a backyard crop, primarily for domestic use .

Because it is not considered a main crop, cultural techniques are often neglected. There has been no varietal improvement work reported since 1967 except a collection of avocado varieties that are maintained at Hung Loc Agriculture Research Center, Dong Nai province, by Professor V.C. Hau. The harvesting and handling techniques are poor, fruits are often picked prematurely and do not give their best quality. Thus, avocado fruit prices are not stable and often are very low compared to other tropical fruits.

However, the avocado has recently received the attention and interest of the government agricultural departments as well of the research institutions, primarily due to its high nutritive value. A research network under the collaboration of various horticultural research institutions, which is coordinated by SOFRI, has been set up to focus on surveys and clonal selection which includes avocado, durian, longan, mango, pommelo, grape and lychee.

3. PRODUCTION OF PLANTING MATERIAL

Seedlings are the most popular type of planting material used in the country. Farmers sow the seeds which are selected from good mother trees . The seedlings prepared by the farmers for their own use are sometimes exchanged among local farmers. As a result, the tree and fruit characters are highly variable in the local avocado population. Seedlings also have a further disadvantage as the avocado is polyembryonic and could produce plants from genetic embryos which are always heterogeneous, causing more variability.

Some Vietnamese documents describe the advanced propagation methods on avocado which are currently practised only in horticultural research stations for research purposes. Since the advanced methods of plant propagation have been well and widely practised in the country to produce millions of plants for other fruit crops, it can be explained that the problem in avocado planting material production is not due to technical problems but to other constraints such as the low price for the fruit.

4. ESTABLISHMENT OF ORCHARDS

Most avocado orchards are in the highlands of southern Vietnam where the natural conditions are favourable for its performance. However, water sources for irrigation are scarce and rainfall is not well-distributed throughout the year. To support the development of young plants, often the planting season starts from the onset of monsoon rains during the months of June and July. At one time, the few monocrop avocado orchards were planted with a density of 160 - 200 trees/hectare at the spacing of 6 x 10 metres or 6 x 8 metres. But when avocado was no longer considered as the main crop, the original density was later reduced by thinning to allow for the development of a main crop like coffee, durian,

mulberry, rambutan, etc. Most of the present avocado orchards have a density of 50-80 trees/hectare (Truyen V.T., 1999).

To establish a new orchard, the plot is first cleaned before laying out the planting system to locate the pit positions. The pits, sized 0.6 x 0.6 x 0.6 metres are prepared, then filled with 20-25 kg manure, 0.5-1kg lime and 0.3-0.5 kg superphosphate about 1-2 months before planting. Among the home produced seedlings, selection was done to chose the healthy ones. However, the A or B type varieties based on their flower opening and closing habit are not well-known to the growers, thus mixing the two types to obtain good fruit set usually has not been carried out. As a result, fruit set and yield of most avocado trees are not satisfactory.

After establishment, the young plants are shaded by bamboo sheet, banana leaves, etc. Tree basins are mulched by dried weed and straw during the next dry season. The water sources are streams and wells which are taken for irrigation during the dry season. Generally, establishing a windbreak system is not practised. On the other hand, to limit the erosion on sloping land and to collect water from rainfall, water traps are made surrounding the tree basins. The shallow, triangular path connecting to the tree pit is dug with its open mouth on the reverse slope direction to collect rainwater.

5. CARE AND MANAGEMENT OF AVOCADO TREES

Since the present avocado crop is not very profitable to the grower because of its low price, it is planted as a shade tree in the orchards of other high value crops, or as border row to separate orchards, and around homes for domestic consumption. Hence, care and management of the trees are not carried out properly.

5.1 Training and pruning of plants

The young avocado plants are normally headed back to promote lateral shoot growth. Pruning for mature avocado trees is not carried out to improve fruit yield and quality but to regulate branch-spreading. Disease-infected and broken branches are pruned to avoid the transmission of diseases or to prevent mechanical damage to the main crop. However, sometimes root pruning is carried out on avocado trees to minimize their nutrient competition with the main crop. Avocado trees enjoy better growing conditions when they are used as shade trees in coffee plantations where fertilizers and irrigation are well-provided to support the high-value main crop.

5.2 Application of manures and fertilizers

Avocado trees benefit indirectly from the cultural practises applied to the main crop. Thus, fertilizer application, weeding and irrigation regimes for avocado trees are practices to be varied from orchard to orchard, depending on what main crop is grown in mixed orchards (Table 3).

Table 3. Rate of Fertilizer Use in Various Cropping Systems (Truyen, 1999)

No.	Cropping System	N-P ₂ O ₅ -K ₂ O (Kg/ha/annum)	Location
1	Coffee-avocado	230-160-110	Lam Dong, Dac Lac
2	Durian-avocado	115-160-110	Lam Dong
3	Jackfruit-avocado	92-80-55	Lam Dong, Dac Lac
4	Monocultivated avocado	nil	Lam Dong, Dac Lac

5.3 Weeding and mulching

Earlier, weed control was accomplished mostly by hand and the weed residue was used as mulching material. Recently, herbicides such as glyphosan and glyphosate have been used for weed control. When the coffee-avocado orchard is well-established, the shoots of coffee overlap and weed control is no longer considered necessary, both for the host and for intercrop plants. Also, avocado trees are removed gradually, when the shading for the main crop is no longer needed.

5.4 Supplementary irrigation

Ground water is the main source for irrigation in the highland areas. Therefore, wells can be found in most farms. Moreover, to limit the water loss through evaporation during the four to six months of dry season, the tree basins are mulched with weed residue, banana leaves, straw, etc.

5.5 Control of pests and diseases

The important pests and diseases affecting avocado trees in the country are Phytophthora root rot, mealybug and leaf-eating caterpillar. Some other pests and diseases affecting the fruit have been recorded also but are not as serious.

The fact that avocado is very sensitive to waterlogging, which predisposes trees to Phytophthora root rot disease, is the reason why it is not widely growing in the Mekong Delta where floods appear once in 3-4 years. However, trees in the highlands of Vietnam are also facing the hazardous Phytophthora disease. Also, the disease was reported to be transmitted from avocado to other crops like durian, papaya and cacao. In practice, usually the disease can be eliminated by applying Ridomil, Alliette or copper oxychloride as a paste. Otherwise, the trees in decline are cut down when the infection is severe. Cercospora spot, stem-end rot and anthracnose can also affect fruit after harvest.

When mealy bug is found to be severe during the dry season, it is controlled by pruning the affected branches and combining with chemical sprays such as Hopsan and Hinosan, while a systemic pesticide like Basudin is also applied. Leaf-eating caterpillar causes the most severe damage on avocado trees in the country. It is often found in the months of February and March. During that period, many avocado trees have been observed with severely damaged foliage due to this problem. However, it has been found that the insect causes damage only on avocado and banana but not on other crops such as mango,

durian, persimon, tea and coffee standing in the same orchard. It can be controlled rather easily by the use of a pesticide spray or pesticide-soaked cloth wrapped around the tree trunk when the pest is still in the larva stage and moves from tree to tree. Stem borers and crickets causing damage to trunk and roots have been recorded also.

6. HARVESTING OF FRUIT AND YIELD

As mentioned earlier, avocado is grown in the Central Highlands, far away from main cities where the fruit could be consumed on a large scale. Fruits are harvested when they are still immature in order to prolong their shelf-life during long distance transportation, often under poor packaging and handling techniques. Fruits are picked manually and usually the fruit maturity index is determined by the pickers, who decide on the harvesting time based on their own experience. Up to the present time, very few investigations have been carried out on productivity and no statistical information has been given officially. Therefore, under the current situation, low and unstable productivity and poor fruit quality are the main concerns of the avocado production development programmes in the country.

7. MARKETING

Avocado fruits are available in Vietnam from February to August, but the main fruiting season is from May to July. The price of avocado fruit is very low compared to other fruits (Table 4).

Table 4. Average Farm Price of Some Fruits in South Vietnam (Feb.1999)

No.	Fruit	Price (VND*/Kg)	Place
1	Water apple	1,200-1,500	Tien Giang
2	Sapodilla	5,000-7,000	Tien Giang, Can Tho
3	Guava	1,000-1,200	Tien Giang
4	Star apple	4,000-6,000	Tien Giang
5	Mandarin	6,500-7,500	Tien Giang
6	Mango	12,000-18,000	Tien Giang, Ben Tre, Dong Thap
7	Longan	15,000-19,000	Tien Giang, Vinh Long
8	Soursop	9,000-13,000	Tien Giang, Long An
9	Banana	500-2,000	Tien Giang
10	Pineapple	1,200-1,500	Tien Giang, Long An
11	Papaya	1,000-1,200	Tien Giang, Dong Thap
12	Water melon	4,000-6,000	Tien Giang, Long An, Can Tho
13	Avocado	300-1,000	Lam Dong, Dac Lac

1US\$ = 13,900 VND

Source: SOFRI, 1999

Vietnamese people rarely enjoy avocado fruit with its natural taste whereas they do in the case of other fruits. Avocado is usually mixed in fruit cocktails, ice cream or in salads. Therefore, it is consumed not as much as other fruits in the country but just in small amounts. The growers send their fruits directly to local markets or to local wholesalers

without grading. To avoid partly the post-harvest losses due to transportation damage, fruits are picked always when they are still green, without good maturity indication. Bamboo containers are mostly used to pack the fruits. From farmhouse to market, the fruits are transported by whatever means that the farmer can manage, i.e. on foot, buffalo-pulled cart, tractor, etc. From the wholesaler to markets in other cities and towns, the common means for fruit transportation are the goods-carrier trucks. Avocado fruits can be seen available not only at their production places but also in many cities and town markets in the southern part of Vietnam. The current price is about US\$40 - 100/tonne at the farm-gate while in the local market it costs about US\$200 - 300/tonne. The price is much lower than for other fruits and varies according to the season, variety and place.

8. POTENTIAL, CONSTRAINTS AND GOVERNMENT POLICIES FOR AVOCADO PRODUCTION DEVELOPMENT IN THE COUNTRY

Since the achievement of national food security, the fruit industry, due to its high profitability to growers, is strongly supported by the government. It is currently recording a fast expansion growth rate of 3.4% per annum.

The Mekong Delta is currently the main source of fruit supply to Vietnamese consumers, but it is predicted that the upland part of Vietnam, including the southeastern and central highland provinces will play an important role in future fruit production activities. It will take a significant share of the fruit industry of the country, both in terms of area and production. The farmers now grow not only traditional fruits like bananas, mangoes, citrus, etc. but also other fruits. Avocado will gradually assume an important position when consumers are made aware of its high nutritive value.

However, to promote the development of avocado production further, the following constraints must be properly addressed. The natural taste of avocado fruit is not preferable to Vietnamese consumers when compared to other tropical fruits. This may be due to the lack of a varietal improvement programme that could attempt to improve its palatability. Avocado fruits cannot gain any price advantage in the market, which makes the avocado crop unprofitable to the growers. In addition, poor handling techniques cause a high post-harvest loss and shorten the shelf-life of fruits.

To solve the above problems, some support has been provided by the government in recent years. Work is being carried out by different horticultural research institutions, coordinated by SOFRI, to evaluate the present genetic resource base of avocado in the country. Furthermore, new promising varieties are being introduced to improve the fruit yield and quality. Some studies are also being carried out by the Southern Fruit Research Institute (SOFRI) on the A and B type avocado varieties, to upgrade present cultural practices and improve the harvesting and handling techniques. Avocado is now considered by the State planners as one of the seven most important fruit crops in the country, due to its high nutritive value and potential export market. Under this support programme, part of the ADB loan will be shared to promote the avocado culture in the country.

9. CONCLUSIONS

Though the first introduction of avocado was reported to have been a great success, its production is still limited due to various reasons. The technical and other constraints (poor propagation methods, unsatisfactory cultural and handling practices, lack of good varieties, and low prices) which are adversely affecting the development of this crop can be overcome. However, the avocado crop in the country needs more attention and investment to exploit its potential fully. The suggested support schemes include: a) long-term loans to the farmers to rehabilitate their multiple-crop orchards, b) more extension support to promote the application of advanced production techniques, c) introduction of new and promising varieties, etc. If avocado culture is better organized along these lines, a positive impact on avocado production can be expected in a few years time.

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