'AHR · COLLEGE OF TROPICAL AGRICULTURE AND HUMAN RESOURCES · UNIVERSITY OF HAWAII

# PROCEEDINGS:

## 4th ANNUAL HAWAII TROPICAL FRUIT GROWERS CONFERENCE

September 30 – October 2, 1994
Kona Surf Resort
Keauhou, Hawaii

# Proceedings:

# Hawaii Tropical Fruit Growers Fourth Annual Conference

September 30 – October 2, 1994
Kona Surf Resort, Keauhou, Hawaii

## PREFACE

The issues addressed at the conference – marketing, promotion, research funding, and quarantine disinfestation treatments – all need to be dealt with in the course of the development of a Hawaii specialty fruit industry.

The keynote speaker, Dr. Mohamad bin Osman, gave a detailed and interesting account of Malaysian fruits and the marketing of the commercialized fruits. It is useful to note that the growth of the Malaysian fruit industry started when it was targeted by a national agriculture policy in 1984. Dr. Mohamad has an M.S. degree in genetics from the University of California at Davis and a Ph.D. in plant breeding/genetics from the University of Wisconsin. At the time of his participation in the fruit conference, he had just completed his tenure as Director of the Fruit Research Division of MARDI, a position he held from 1990 to 1994.

Editor: C. L. Chia
Extension Specialist in Horticulture
Department of Horticulture
College of Tropical Agriculture and Human Resources
University of Hawaii at Manoa

Cover: Multiple shoots of carambola (*Averrhoa carambola* L.) from cotyledon culture. Photo courtesy of L. Agus Sukamto.

# Fourth Annual International Tropical Fruit Conference

September 30 - October 2, 1994
Kona Surf Resort, Keauhou, Hawaii

*Sponsored by the*
*Hawaii Tropical Fruit Growers,*
*University of Hawaii College of Tropical Agriculture and Human Resources,*
*County of Hawaii Department of Research & Development*
*Governor's Agriculture Coordinating Committee*

## PROGRAM

### FRIDAY, SEPTEMBER 30, 1994

5:00 pm **Mauna Kea Gardens**
Registration, Heavy pupus,
No-host bar and Poster session

7:30 pm **Tropical Fruit Crops of Malaysia**
Dr. Mohamed Osman,
Director of Fruit Research
Malaysia R & D Institute

### SATURDAY, OCTOBER 1, 1994

8:00 am **Registration**

8:30 am **Annual Membership Meeting** - Lesley Hill

9:30 am **Welcome from Governor's Office**
Robert Robertson

10:00 am **Future Development of Tropical Fruits in Hawaii**
Diane Quitiquit, Director
County of Hawaii, Department of R & D

10:30 am BREAK

10:45 am **Global Marketing of Malaysian Fruits**
Dr. Mohamed Osman
Director of Fruit Research
Malaysia R & D Institute

11:45 am **Treatments for Export of Hawaii Tropical Fruits**
Dr. Jack Armstrong, et al, USDA/ARS

12:30 pm LUNCH

1:30 pm **Future of Research & Promotion Programs in Hawaii**
Panel facilitated by Brian Lievens

**Funding and Development of Research and Promotion Programs**
Jo Ann Smith, Exec. Dir. of the Pecan Marketing Board and former Asst. Sec. for USDA/Mkting & Inspection Services

**Benefits of Generic Promotion**
Tom and Ann Thacker, Principals
The Thacker Group, Kona & CA-based public relations firm specializing in generic promotion of Ag commodities.

**Hawaii Department of Agriculture's Role in Marketing and Distribution of Ag Products**
Samuel Camp, Manager, Hawaii Department of Agriculture, Commodities Branch

**Australian System of Funding Research and Promotion**
Dr. H.C. "Skip" Bittenbinder, UH/CTAHR
Ext. Specialist for Tropical Fruits & Nuts

3:00 pm **Fruit tasting and social hour**

6:00 pm **No-host cocktails, dinner and auction**

### SUNDAY, OCTOBER 2, 1994 - FIELD TRIP

8:00 am **Bus leaves Kona Surf Resort**
Ka'aina Pono, Honaunau - Craig Elevitch
South Kona Orchard
Brian Lievens - Irrigation
Brian Paxton - Varieties of Tropical Fruits
Kona Experiment Station
Marc Meisner, Farm Manager
Varieties of tropical fruit & ground covers

1:30 pm **Keahou Yacht Club - LUNCH**

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MESSAGE FROM GOVERNOR JOHN WAIHEE

September 30 - October 2, 1994

It is a pleasure to extend my greetings, and my warmest aloha, to everyone who has gathered for the Fourth Annual International Tropical Fruit Conference in Kona on the Big Island of Hawaii.

Tropical fruits such as atemoya, star fruit, lychee, and mango are enjoyed as delicacies throughout the world. In 1993, Hawaii's tropical specialty fruit production totaled nearly 500,000 pounds. I am happy to know that this conference will focus on furthering the education of growers, marketers, and consumers of tropical fruit.

You will hear national and international experts share information about research, development, and promotion programs. Their knowledge will be sure to inspire and stimulate each of you.

I commend the Hawaii Tropical Fruit Growers for sponsoring this conference, and wish you all an enjoyable and productive meeting of the minds.

JOHN WAIHEE

# Future Development of Tropical Fruits in Hawaii

**Diane S. Quitiquit**
**Hawaii County Department of Research and Development**

Good Morning! Thank you for inviting me to this conference. I am asked to speak to you this morning about the Future Development of Tropical Fruits in Hawaii. Let me begin by stating that, the Big Island will continue to be the production center of tropical fruit in the State. And this is why.

Current statistics on tropical specialty fruit show that in 1993, a total of three hundred and ninety acres were planted with tropical specialty fruits statewide. Of this total, two hundred and fifty acres or 64% is on the Big Island. The number of acres in tropical specialty fruit on the Big Island is increasing by 11% per year. The farm value of this new and progressive industry is $136,000 per year.

The closing of the commercial sugar production on the Hamakua Coast and the upcoming closure of the Ka'u sugar on September 1996, will release approximately 66,600 acres for other crops. Tropical fruits will play a major role in the utilization of these lands. Just how available and affordable these lands will be to farmers is a question that is in everyone's mind. Let me update you on how the County is working to address this question.

The County is working on legislation which will establish separate subdivision standards for farm lots. It is hoped that with these new rules, landowners will be able to subdivide their lands without meeting the strict requirements of the Subdivision Code, so that they will be affordable to farmers. Moreover, the current real property tax assessment for agricultural lands is being examined to find ways of simplifying it to encourage diversified agriculture.

However, having land alone does not create an industry. We also need hard working visionary farmers. The Big Island is fortunate to have visionary and hardworking farmers who are attracted to tropical fruit farming. The 1993 statistics show that there are fifty growers of tropical fruits on the Big Island compared to twenty-five growers in the rest of the State.

These seventy-five growers ought to be congratulated for bringing an unknown industry into existence and making it a promising one. These are the breed of farmers we need on this island; hard working and committted to making things happen.

The Big Island farmers who are here today must sense the bright economic promise of tropical fruit, otherwise their attendance at this conference would not be this impressive. The time and money they have invested in this conference speak of their willingness to venture into this new industry despite the many unknowns.

Except for mango, kiwifruit and persimmon, the markets for other tropical fruits are not developed. This is where the visionary attribute of the Big Island farmers will come into play. Your choice of market, either local, export, or both, will dictate the future prospects of the industry. If you restrict yourself to the local market, your potential for expansion will be limited. Your real potential lies in developing the export market.

As all of you know, tropical fruits grown in Hawaii are hosts of tephritid fruitflies. As such our fruits are prohibited from entering the mainland U.S. due to the potential damage that the flies may cause to their agriculture. The biggest challenge that the industry will face in the export market is developing fruitfly treatments applicable to each type of fruit. Unfortunately, each fruit has its unique characteristic such that it requires individualized treatment. To develop a fruitfly treatment takes a long time. It took five years for carambola.

We are very fortunate to have on the Big Island a facility and a group of committed experts whose mission is to develop suitable commodity treatments for use on fresh fruits and vegetables against fruitflies and other quarantined insects. Making the Big Island fruitfly free, if it can be done, would be the best solution for the export market. However, such an ambitious endeavor will be difficult to achieve due to the large numbers of host materials existing in Hawaii and the flies are already established throughout the islands.

There are already existing technologies that show great potential for treating fresh fruits with such delicate characteristics. These techniques include direct treatments such as the use of fumigants, heat, cold and irradiation and multiple treatment which uses a combination of heat and cold.

The industry has to evaluate the merits of each of these techniques and choose the one that shows less damage to your fruit. A wise choice will have a great impact on the future destiny of this industry. Therefore, choose wisely.

The County has always been supportive of diversified agriculture. My department does not only provide financial support to Big Island commodity groups in carrying out their programs but also act as a conduit between the agriculture community and the various government agencies.

We have been very supportive of your industry since its inception. We have provided financial assistance to enable your industry to invite international experts to your conferences. We plan on continuing our support of the tropical fruit industry.

Once again, thank you for inviting me to participate today and I wish you a very successful conference.

# Tropical Fruit Crops of Malaysia

**Mohamad bin Osman**
**MARDI, Serdang, Selangor, Malaysia**

**Introduction**

In Malaysia, fruits are steadily becoming an important component of the agricultural production. Our processed pineapple has been in the world market for decades. In fact, since the late 1980s, the fruit industry began to command a small but important niche in the international export market for fresh starfruit. The country is probably close to becoming a net exporter of fruits, with the exports of fresh and processed fruits showing upward trends in recent years. In 1992, the export values increased to US$58.1 and US$40.1 million, respectively. The main fruits exported were pineapple (32.8%), durian (22.2%), starfruit (9.6%), papaya (9.6%), watermelon (9.1%) and banana (5.4%), and together these fruits contribute 89% of the total fruit export value.

This paper briefly describes the fruit industry in Malaysia and the cultivars grown commercially in the country. It also highlights the diversity of tropical fruits found in the country and some of the potential minor and rare fruit types.

**The Fruit Industry**

At present, the country's economy is strongly fuelled by the manufacturing and industrial sector as the engine of growth. Agriculture remains important, but has steadily experienced a decline in its contribution towards the Gross Domestic Product.

Based on the export earnings, fruits are still considered as relatively minor crops in the country. It is envisaged that the country's agriculture will continue to be dominated by rubber, oil palm and cocoa amongst the plantation crops, and rice amongst the food crops. And this crop mix pattern is likely to change slowly in the years ahead. It is expected that fruit production will remain behind the status of any of the plantation crops, both in terms of priority accorded and their scale of operation.

However, the future for fruits is bright because they have the potential to contribute towards the country's earning, indirectly through import substitution and directly as an export commodity.

Overall, the potential for growth of the fruit industry can be exploited from three main areas: (1) the domestic fresh fruit demand; (2) the export of tropical fruits; and (3) processing.

Before the National Agricultural Policy (NAP) was launched in 1984, there were no specific policies for the development of the fruit industry. The industry at that time consisted of about 135,000 smallholders with poor economy of scale of production and widely dispersed. With the directions of the NAP, fruit was selected as a commodity to be given the thrust for development in the agricultural sector. This was in line with the Government's policy to promote commodities which have high added values and good export potential.

The supportive government policies had given the fruit industry the necessary impetus for accelerated development, and had encouraged the commercial production of fruits for local consumption, export and processing. The growth of the fruit industry further gathered momentum with the active participation of the government and private sectors. While these were happening, the efforts of some traditional plantation agencies in the private sector which had earlier pursued diversification opportunities by experimenting with large scale fruit cultivation in the late 1970s, also begun to bear fruits. Table 1 shows the involvement of public agencies and private growers involved in the commercial fruit production in Malaysia in the last five years.

The area for fruit cultivation had increased rapidly from 121,000 hectares in 1984 to 180,000 hectares in 1990, or almost 50% increase in hectarage in about seven years. The bulk of the present fruit production is still produced in the smallholdings and in home gardens. In essence, this increase was largely due to rehabilitation of old stands, and only recently it was due to commercial plantings. At present, durian is the most extensively planted fruit in the country, accounting for 61% of the hectarage increase and 34% of the total hectarage. However, more recent trend of expansion has included starfruit, papaya, Cavendish banana and citrus as well.

**Tropical Fruits: Their Profile**

Tropical fruits in Malaysia comprise more than five hundred species of both edible and

**Table 1. Commercial fruit production in Malaysia in the past five years.**

| Public/Private Growers | Hectarage | Fruit types |
|---|---|---|
| Durian-dominant | | |
| Felcra (Kota Tinggi, Johor) | 250 | Durian/rubber intercrop, others |
| Dusun Labu Valley, (Nilai, N. S.) | 90 | Durian, jackfruit |
| Eden Farm (Tapah, Perak) | 100 | Durian |
| Seng Hock Farm (Bt. Selambau, Kedah) | 80 | Durian, mango |
| Felda - PKPF (Bt. Cerakah, Selangor) | 120 | Durian, jackfruit, starfruit, ciku, mangosteen, soursop |
| Mangosteen - dominant | | |
| Perak Fruit and Dev. Corp. (Sungkai) | 120 | Mangosteen, durian |
| Dokong-dominant | | |
| Bukit Jelutung Farm (Terengganu) | 60 | Dokong |
| Manggo - dominant | | |
| Perlis Plantation (Chuping, Perlis) | 120 | Mango |
| Tenusu Jadi Farm (Bt. Selambau,Kedah) | 80 | Mango |
| IADP (Perlis) | 240 | Mango |
| Starfruit - dominant | | |
| PKPS (Puchong, Selangor) | 120 | Starfruit, jackfruit, soursop |
| Vita Tenggara (Kota Tinggi, Johor) | 240 | Starfruit, mango, durian, soursop |
| Crystal Farm (Bidor. Perak) | 20 | Starfruit |
| Felcra (Sg. Bunga) | 20 | Starfruit |
| Bounticrest Farm (Kluang, Johor) | 20 | Starfruit |
| Far East Holding (Maran - Pahang) | 200 | Starfruit, banana, citrus (mandarin) |
| Citrus - dominant | | |
| IADP - (Samarahan, Sarawak) | 200 | Citrus (mandarin) |
| Koperasi Pembangunan Desa (Sabah) | 60 | Citrus (mandarin), passion fruit |
| Prudence Nursery (Segamat, Johor) | 8 | Citrus - mandarin planting materials |
| Guava - dominant | | |
| Golden Hope (Bt. Lawang, Johor) | 240 | Pinkguava, calamondin |
| Ciku - dominant | | |
| Felcra (Sri Makmur) | 10 | Ciku |
| Felcra (Cempoh) | 6 | Ciku |
| Pineapple | | |
| PCM - (Pekan Nanas, Johor) | 800 | Pineapple |
| Lee Pineapple (Sg. Rengam, Johor) | 2,800 | Pineapple |
| Banana | | |
| Johor Tropical Product (Johor) | 400 | Cavendish banana |
| United Plantation (T.Intan, Perak) | 100 | Berangan banana |
| Papaya - dominant | | |
| Agromaju (Bandar Tenggara, Johor) | 160 | Papaya, starfruit, citrus (mandarin) |
| EPA (Ulu Tiram, Johor) | 80 | Banana and papaya |

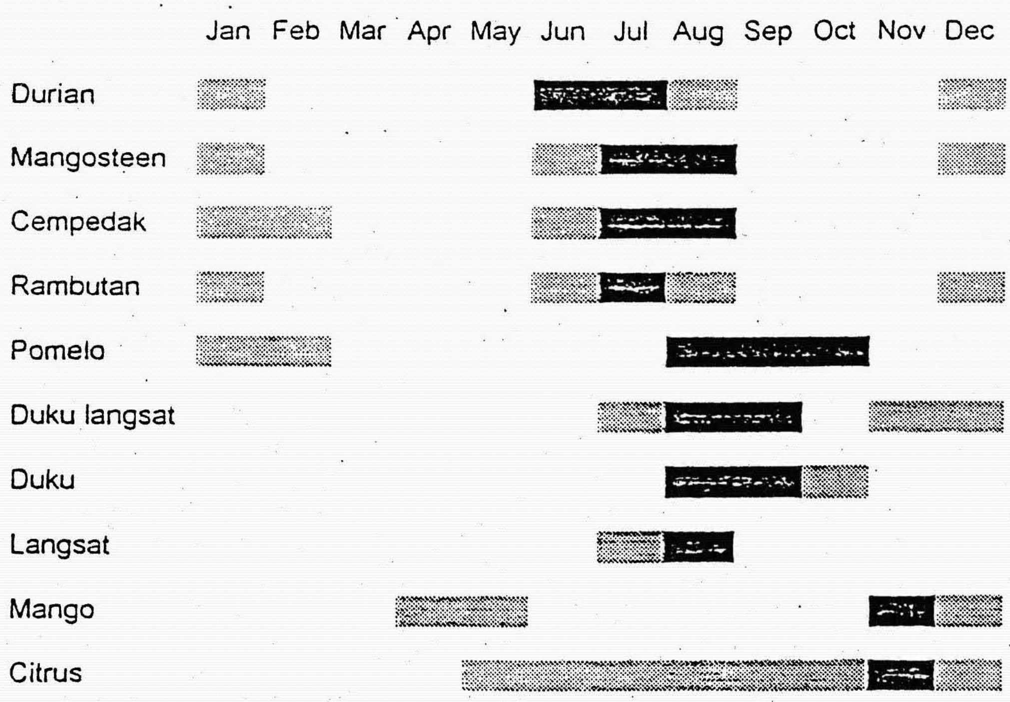


**Figure 1. Fruit seasons in Malaysia.**

inedible ones, including related wild fruit species. Of these, it is estimated about one hundred and fifty species are either cultivated or whose fruits are harvested from the wild for consumption and other uses.

Like rubber, oil palm and cocoa, the fruit industries in Southeast Asia have also benefited from the efforts of early settlers and traders. Many important fruit types were introduced from other tropical regions. For example, pineapple and papaya industries started with the introduction of these species from Central America. Guava, ciku and soursop were introduced from South America, jackfruit from India, while watermelon was from South Africa. In fact, due to the multitude of agro-ecologies and socio-economic influences, even the introduced fruit species, such as guava and papaya, have accumulated considerable diversity locally (Singh, 1993).

The fruits cultivated in Malaysia can generally be grouped into two broad categories, namely:

**Non-Seasonal Fruits:** banana, ciku, citrus, guava, honeydews, jackfruit, papaya, pineapple, starfruit, soursop, watermelon;
**Seasonal Fruits:** cempedak, dokong, duku, duku langsat, durian, mango, mangosteen, rambutan.

From the commercial point of view, Malaysian fruits can be further categorised into three groups based essentially on the number of years each group takes to bear. The group with a long juvenile period takes between six to twelve years, the intermediate between two to five years, and the short less than two years. Many non-seasonal fruits such as papaya, banana and melons have short juvenile periods, in contrast to seasonal fruits which usually have intermediate to long juvenile periods, for example, mangosteen and dokong.

In the strict sense, many non-seasonal fruits do not actually produce continuously throughout the year but exhibit one or several peak bearing periods. For example, guava, ciku and starfruit are known to have two to three bearing periods in a year. For seasonal fruits, some of them exhibit biennial bearing such as duku langsat.

In Peninsular Malaysia, the main seasons of many fruits are observed to occur in the mid-year or few months thereafter. Durian, rambutan and mangosteen often fruit about the same time, and the main seasons normally overlap in the months of June through August (Figure 1). Seasonal fruits usually produce heavily in the main season, but some may also produce in minor seasons depending on the agro-ecological environments where they are grown. As an example, the period in which durians are available gets extended because the fruit season in the West Coast is normally followed about a month later by the fruit season in the East Coast.

Virtually all the tropical fruit crops can be propagated vegetatively, but to a large extent many growers still propagate from seeds, except for some which are seed propagated fruit species such as papaya and melons. Dokong, duku, duku langsat and mangosteen are known for their apomictic behaviour, including polyembryony. Even though they can be clonally propagated, they are invariably raised from seeds to avoid the problem arising from rootstock-scion incompatibility, particularly for mangosteen. Durian and starfruit are examples of cross-pollinated fruits, and therefore require suitable pollenizer cultivars to enhance fruit quality and production. And as for soursop, assisted pollination has been found to be required to improve the presently poor fruit yield and quality.

**Brief Descriptions of Some Important Tropical Fruits**

**Pineapple** (*Ananas comosus*)

Pineapple is now widely distributed in the tropics and sub-tropics. The succulent fruit is a popular dessert, and it is also canned as slices, cubes, cocktails or juice. Notable producing countries are the Philippines, Thailand, Hawaii, Ivory Coast, Kenya, South Africa, Malaysia, Taiwan, Vietnam and Australia. In Malaysia, 11,500 hectares are grown, concentrated on the peat areas of West Johor. The major cultivars grown are Gandul (in estates) and Masmerah (in smallholdings), and are grown mainly for canning in making slices and cubes. The best eating and the most popular fresh cultivar is the Nanas Moris (Mauritius).

**Durian** (*Durio zibethinus*)

Durian, also known as the "King of Fruits", is one of the best known fruits in Asia and is a gourmet's delicacy. The fruit, weighing from one to five kg with large thorns on the skin, has a delicious, creamy pulp inside. It is also known for its strong and pungent odour which can be offensive and nauseating to some people. It is widely cultivated and is the most popular fruit in Southeast Asia. In Malaysia, durian is one of the fruits with the highest export value. Besides consumed as fresh fruit, the durian is also processed into products such as cakes, candies, wafers and flavouring powder in ice creams, jams and others.

The total area planted with durian is about 50,000 hectares with production of more than 250,000 tons. There are nearly two hundred clones available in the country, but only a small number of them are utilized by the growers. At present, the popular clones being planted include D24, D99, D123, D145, D158, D159, D169, MDUR 78, MDUR 79, and MDUR 88.

**Starfruit** (*Averrhoa carambola*)

The starfruit is named as such because a cross-section of the fruit looks like a star. The fruit is native to Malaysia and Indonesia, and has spread to India, Philippines and other countries in Southeast Asia. Starfruit, or *carambola*, is an attractive small tree which produces fleshy five-angled fruits having a sweet to sour taste, and are eaten fresh or used in salad, for drink, jellies and preserves. The total area under starfruit is about 450 hectares with two popular cultivars, namely B10 and B17 with their pollenizer clones, B2 and B11.

Growing starfruit can be profitable but labour intensive. Apart from the local market, starfruit has also found a growing and lucrative markets in Hong Kong and Europe. There is also an emerging market in Canada.

**Papaya** (*Carica papaya*)

Papaya has long been popular not only in the tropical countries but also in the other parts of the world. Its fruit is eaten fresh, and is excellent in taste and nutritive value. Papaya is also processed into preserved foodstuff such as juice, nectar, puree and others. Locally, the type of fruits in demand is the one with orange to red flesh, sweet and juicy. There are many local and introduced varieties of papaya in Malaysia. At present, the popular varieties include Eksotika, Eksotika II, Batu Arang and Subang 6. Before the incidence of papaya ringspot virus more than two years ago, the area planted with Eksotika was estimated at more than 600 hectares.

**Watermelon** (*Citrullus vulgaris*)

Cultivation of watermelon in this country has increased substantially in the last ten years. Watermelon is consumed fresh, in form of juice or salad, is popular among the Malaysians, and has good export potential. Propagation is through the use of imported commercial seed varieties, and the popular varieties grown include Seedless variety, Fenghsan No. 1, Flower Dragon, New Dragon, New Sugar Baby and Yellow Baby.

**Rambutan** (*Nephelium lappaceum*)

The rambutan tree is native to Malaysia and Indonesia. It is cultivated for its tasty fruit. The oval fruit is about the size of a hen's egg and has bright red to yellow colour. It is presently grown in many countries in the Southeast Asian region, especially Thailand, which has become the leading producer of the fruit.

Most of the rambutan grown in the country is consumed fresh, and canned in syrup. The total area under rambutan is estimated to be more than 20,000 hectares. There are more than 180 rambutan clones, but the ones released for general planting include R3, R134, R156, R160, R161, R162, and R170.

**Mangga** (*Mangifera indica*)

Mango is one of the popular fruits in the tropics and sub-tropics, and has an aromatic flavour and taste. The fruit is eaten fresh or processed into juice and various products such as pickles, jams, jellies, vinegar and dried fruits.

Growing mango in the suitable agro-ecological zones is an important pre- requisite for good production because fruit setting is a problem. Mango is suited in the area where there is a distinct dry period, usually in the north. Initially, most of the introduced cultivars were from India, but later cultivars from Indonesia, Thailand and others were brought in. Current mango clones available include MA128 (Harumanis), MA162 (Golek), MA165 (MAHA 65), Nam Dok Mai, Masmuda and Chokanan.

**Cempedak** (*Artocarpus integer*)

The cempedak is an evergreen tree which produces seasonal fruits. The ripe fruit is sweet, has a pleasant (or pungent) smell, and the flesh is waxy and golden yellow in colour. It has voluminous seeds and the pulp is eaten fresh, fried or processed into products. There are about 8,000 hectares of cempedak in Malaysia. Several good clones include CH27, CH28, CH29, and CH30.

**Jackfruit** (*Artocarpus heterophyllus*)

The jackfruit is a fast growing latex producing tree which produces fruit all year round. An average tree can yield between 30 to 250 fruits per year, and each fruit is big, weighing between 9 to 32 kg. The fruits are eaten fresh when ripe, and the immature fruits can also be used for cooking. There are about 2,000 hectares of jackfruit in Malaysia, and the two popular cultivars are NS1 and J29.

*Lansium domesticum*

The *Lansium* species are cultivated as a garden crop in Southeast Asia, and is almost unknown outside the region. They are native of Malaysia, Philippines, Thailand and Indonesia. The fruits are mostly locally consumed and do not store for long after harvest.

It is estimated that there were about 8,000 hectares of duku, langsat, duku langsat and dokong. It is one of the slowest growing trees, and may need seven to ten years before the trees reach bearing stage. There are no recommended clones, but selected trees are normally propagated through seeds or grafted plants; they are apomictic.

**Mangosteen** (*Garcinia mangostana*)

Mangosteen is one of the most delicious tropical fruits, and is named "Queen of Fruits." The fruits are consumed fresh, but the edible portion can also be canned and processed. Mangosteen is grown in most part of Southeast Asia, but often as a minor component in mixed crop planting. The trees require fairly high rainfall, humidity and well-drained soil.

Being apomictic, mangosteen can be propagated from seeds without producing variable fruit characteristics, and the practice of the growers are to raise mangosteen from seeds. Only large seeds are used for producing good seedlings. The leaves are easily scorched under full sunlight.

Mangosteen has a long juvenile period, and the trees begin to bear fruits six to eight years after planting. The planted area in Malaysia is about 3,000 hectares, and there is as yet no recommended clone.

**Processing varieties**

The Beaumont variety has been recently introduced as a juicing guava variety from Hawaii, besides other selections, such as GU5. For soursop, there are few selections that have been recommended for planting, namely DB1, DB2 and DB3. Passion fruit seeds are normally imported from Taiwan.

**Toward More Commercial Production: Breeding and Commercial Cultivars**

Inconsistencies in fruit quality and lack of good, dependable varieties have often been

**Table 2. Some suitable cultivars of Malaysian fruits.**

| Fruit type | Some suitable varieties | Potential varieties |
|---|---|---|
| Banana | | |
| Berangan | Local | Intan, Novoria |
| Cavendish | - | Montel, Williams |
| Cempedak | CH28, CH30 | - |
| Ciku | Jantung, Subang | CM 20 |
| Citrus | | |
| Langkat | Terengganu | - |
| Pomelo | C41 | KK 2 |
| Duku Langsat | Local | J 35 |
| Dokong | - | Dokong Kering |
| Durian | D 24, MDUR 78, MDUR 79, MDUR 88, D 99* | |
| Guava | | |
| Fresh | Kampuchea | JP 2 |
| Process | Beaumont | GU 5 |
| Jackfruit | NS1 | Isi Merah |
| Mango | Nam Dok Mai 4 | Masmuda, Chokanan |
| Mangosteen | Local | Seedless |
| Melon | | |
| Watermelon | New Dragon, | IS |
| | Shen Shan (seedless) | - |
| Muskmelon | Jade Dew, Sky Rocket | - |
| Papaya | | |
| Fresh | Eksotika, Eksotika II | - |
| Process | Subang | - |
| Pineapple | | |
| Process | Gandul | Selection A20-3 |
| Fresh | Sarawak, Mauritius | M 36, Selection A54-47 |
| Rambutan | R134, R156 | Anak Sekolah |
| Soursop** | | |
| Process | - | DB1 |
| Starfruit | B10, B17, B2* | B11* |

* Pollenizer varieties
** Requires assisted pollination

quoted to be the major set-back in the development on commercial scale of some fruits, particularly those that are seasonal or biennial and have long juvenile periods. Breeding for tropical fruits usually does not have a high priority. For one thing it requires a long-term research commitment and the benefits will only accrue in the distant future. Due to long juvenile periods, the time for breeding work will necessarily take a long time to accomplish. It is, therefore, not unusual that breeders seldom remain to see the results of their initial efforts.

A program to promote the fruit industry is often confronted with the question of which fruit crops to grow and what cultivars to be planted to meet the market specifications - whether for fresh export or for processing. In Malaysia, genetic improvements of many fruits have been made through selection from farmers' plantings after several seasons of evaluation. Since 1934, the Department of Agriculture has been keeping a register on promising fruit clones of cempedak,

**Table 3. Mean annual yield (t/ha) for fruit crops in three countries (1986-87).**

| | Peninsular Malaysia | Thailand | The Philippines |
|---|---|---|---|
| Banana | 8.3 | 3.1 | 11.5 |
| Pineapple | 12.6 | - | 32.8 |
| Papaya | 22.5 | - | 14.7 |
| Citrus | 5.0 | 9.1 | 5.3 |
| Mango | 3.5 | 2.2 | 5.8 |
| Durian | 6.2 | 5.6 | 13.5 |
| Langsat | 9.3 | 4.6 | 2.5 |
| Rambutan | 2.9 | 6.9 | - |
| Mangosteen | 12.9 | 5.2 | 1.8 |
| Jackfruit | 8.7 | 10.5 | 5.2 |
| Cempedak | 10.9 | 12.1 | - |
| Guava | 23.8 | 3.1 | - |
| Ciku | 15.0 | - | 3.9 |
| Sugarapple | - | 4.0 | 3.2 |

ciku, durian, guava, jackfruit, mango, rambutan and starfruit. Needless to say, the selection was not confined only to local materials, but also included introduced materials. Since then many selected ones have become standard local clones now, and have been released to the growers. Table 2 lists the suitable and potential clones that have been selected or bred locally for many of the fruit crops.

For fruits with good export potential such as starfruit and papaya, suitable cultivars are already available. The most suitable cultivar of starfruit for export is B10.

MARDI has bred and released several new varieties of fruits which have been cultivated on commercial scales, namely papaya, durian and pineapple. For papaya, the Eksotika variety released in 1987 was a tremendous success, and boosted papaya export. Eksotika was developed through backcrosses of local cultivar Subang 6 with the Hawaiian Sunrise Solo. In 1991, MARDI released an improved papaya hybrid developed from crossing Line 19 with Eksotika. The new hybrid, Eksotika II, has better yield and fruit cosmetics and also keeps better than its predecessor.

For durians, the first hybrid clones were released in 1991, that is about twenty years after initial crossing. Named MDUR 78 and MDUR 79, these clones were selected from hybrid progenies obtained from D24 x D10 crosses which were first planted in 1969. A year after the release of these two clones, MARDI released another hybrid clone called MDUR 88, also selected from progenies of the cross D24 x D10. The performance and quality of these three hybrid clones are comparable or better than the standard clone D24. However, the new hybrids are found to be tolerant to canker disease caused by *Phytopthora* These three clones have so far been very well received and over 100,000 grafted plants have been sold to the growers.

Since its early years, MARDI has been involved with hybridization and selection of pineapple, papaya and durian. For starfruit and ciku, hybridization has recently been initiated. Selection work is in progress for rambutan and guava. Not too long similar efforts will be undertaken for other fruit types.

Having made the choice as to what fruit types to work on, the next step is to clearly define the breeding objectives. In general, there is a strong emphasis now to develop cultivars for processing and for added value products. In addition to these, certain breeding objectives remain universal, for example high and consistent yields, and good quality characteristics are of great importance. Table 3 shows the yields of a number of fruit types in Malaysia compare with those of Thailand and the Philippines (PROSEA, 1992).

**Production Systems**

The present production systems for fruit cultivation, which are still considered inefficient and labour intensive, need improvement. Some evident areas which are presently pushing up production costs are in fruit bagging (e.g., starfruit, guava, mango, cempedak) and in harvesting (e.g., mangosteen).

Increasing production through efficient pollination is also another area that poses a huge challenge to large scale orchards. On smaller, intensive scales, increased yield and quality of certain fruits such as durian and soursop using hand pollination may be feasible but this may become impractical in large commercial farms. Other methods using suitable pollinators, and pollen sprays for pollination have to be developed under such circumstances.

There is good potential for higher density planting for mango, ciku, soursop, starfruit and others when the proper methods of training and pruning are practiced.

**Pest and Disease Management**

Pests and diseases are often limiting factors affecting fruit growth and production, especially when fruits are planted on large scale where inoculum and pest levels can increase rapidly to epidemic proportion. Orchards are under constant threat from debilitating diseases. The recent outbreak of papaya ringspot virus disease has caused great concern regarding the future of the papaya industry in the country. Virus diseases on passion fruit have also virtually ruled out its commercial potential in the fruit industry. Other diseases that may threaten and curb large scale cultivation are greening disease of citrus, Sigatoka and fusarium wilt in banana and bacterial canker of jackfruit.

For pests of fruits, the major one which threatens the industry is fruit fly, which has done immeasurable damage to soft-skinned fruits like starfruit, ciku, guava and many others. For production of clean, good cosmetic fruits, growers are forced to bag fruits to keep out infestation and this has pushed up production costs. For control of fruit fly, MARDI and ACIAR have recently come out with a new formulation for the protein bait called PROMAR. This is produced from autolysed yeast available as an industrial by-product. This attractant, laced with insecticides, is spot applied on trees at weekly intervals for effective fruit fly control. It is safe on other beneficial organisms and also environment-friendly.

**Long Juvenile Periods**

Papaya, banana and melons are examples of fruits with short juvenile periods. As a matter of fact, the growers treat them as 'cash crops' that can make a quick profit. On the other hand, the fruit types that are seasonal with too long of juvenile periods will not be preferred by the intermediate growers, unless there is a strong market for good payback such as durian and dokong.

In fact, mangosteen, dokong, and duku langsat have long juvenile periods of between six to ten years, which therefore effectively discourage entrepreneurs from investing. An area which holds promise for shortening the juvenility is the use of advanced planting materials (APM).

**Nursery Propagation and Techniques**

Much efforts have been spent on research on propagation techniques for tropical fruits. Grafting techniques using bud, or cleft have been developed for almost all the popularly cultivated perennials. The technology for nursery techniques and propagation is complete for many fruit types. Therefore, there should be effort to encourage the establishment of more nurseries to produce quality planting materials to support the growth of large scale commercial farms in future.

**Diversity of Tropical Fruits**

Southeast Asia region, with a multitude of climatic conditions and agro-ecologies, is one of the most important centres of diversity for tropical fruits. The rich diversity of plant life in the tropical rainforests of the region is a well known fact. Endowed with a conducive climate, the region is reported to have about 25,000 indigenous species of flowering plants. More than five hundred species of fruits are estimated to be found in the region. A wealth of these indigenous genetic resources still remain in the forests, and only a fraction of them are actually grown in cultivation and utilized. In general, many tropical fruits are under-exploited and remain far behind the temperate fruits in terms of their exploitation.

To date, the development of cultivars has generally tapped on the existing variability in the cultivated species, and very few through deliberate breeding programmes.

The region produces the major tropical fruits namely banana, mango, and pineapple as well as some exotic fruits such as durian and rambutan. During 1986-88 period, the region produced most of the minor tropical fruits in world market, accounting for more than 68%.

And Malaysia is unrivalled in terms of its great diversity of fruit genetic resources and is renowned as one of the major centres of origin of the cultivated fruit plants. Many of the important cultivated fruit species have their wild relatives which are found in the rainforests, particularly the large genera such as *Durio* (durian), *Garcinia* (mangosteen), *Nephelium* (rambutan, pulasan), *Artocarpus* (cempedak, tarap), *Baccaurea* (rambai), *Citrus* (lime, pomelo), *Syzgium* (water apple), *Mangifera* (binjai, bambangan), *Musa* (banana), *Salacca* (salak) and others. To evaluate the species richness, Saw et al. (1991) made an inventory of 50 hectares of primary lowland rain forest in Peninsular Malaysia, in which about 340,000 trees 1 cm diameter or larger were measured and identified to species. Out of a total plot tree flora of 820 species, seventy-six species are known to bear edible fruit. Especially diverse were the wild species of mango (twelve species), mangosteen (thirteen species), breadfruit (ten species) and rambutan (five species). Even though there may be more than two hundred fruit species in the forests in Peninsular Malaysia, only a handful of them, about one hundred species, are edible and significant (Hashim, 1987; Lemmens et al., 1989).

**Major, Minor and Rare Fruits**

The terms "major fruits", "minor fruits" and "rare fruits" are relative in their meanings. In the international fruit markets, the tropical fruits are considered minor and exotic compared to the temperate fruits, except for a few of them. Durians, for example, are the major and the most popular fruits in Malaysia and Thailand, and a number of other countries in Southeast Asia, but the fruits are still unheard of in many parts of the world. In Indonesia, salak has already been planted very widely, but it is still rare to see the fruits in this country. Similarly, tarap in Sabah and dabai in Sarawak are popular but only locally. In our context, the major and minor fruits are defined as those that are planted with production in mind, but differing in their relative abundance, while the rare fruits are usually not deliberately planted and may only be found in the jungles and the rainforests, and none or very little of them find their way into the market places. The rare fruits also include those that have become negligible or ignored over time.

Generally, the indigenous fruits can be categorized as follows:

**Major fruits:**
banana, starfruit, mango, durian, jackfruit, rambutan, citrus, duku langsat, dokong, cempedak, mangosteen;

**Minor fruits:**
sukun, kuini, salak*, jambu air+, tarap, bambangan, rambai, duku (Johor), langsat, bacang, binjai;

**Rare fruits:**
pulasan, isau, dabai, sentul^, bidara^, kedondong^, lontar, kabong, buah Melaka, lanjut, cermai, rokam, jambu bol, jambu mawar, perah, engkabang.

(* Popular in Indonesia,
+ Popular in Taiwan,
^ In Thailand).

**Collections and Conservation of Fruit Diversity**

The indigenous plant genetic resources has dwindled as a result of the development by way of logging and conversion of forest land to agriculture or other uses such as mining, construction of dams and urban development. Ever since the establishment of various government bodies, many collection trips have been carried out from time to time. Some of them have done this as part of their conservation or plant breeding programmes. Although many plant species may have been lost forever, many have been collected and maintained by the various research bodies in the country.

The living collections of fruit genetic resources held by different institutions and agricultural parks are indicated in Table 4, either in-situ or ex-situ or both. Overall, these institutions taken together now have more than one hundred and fifty species, with over 4,700 accessions ex-situ. The various institutions that provide for in-situ conservation areas include Forest Research Institute of Malaysia (FRIM), Forest Research Centre (FRC), Sabah and Department of Agriculture (DOA), Sabah. In MARDI, the accessions are basically working germplasms that are being handled by many breeders.

The genetic diversity of fruit genetic resources in Malaysia has already been well documented, particularly by Corner (1988), Whitmore (1972; 1973), Ng (1978; 1989; 1990) and PROSEA (1992). The genetic diversity of the lesser-known fruit species in Sabah, Sarawak and Brunei Darussalam has also been well documented by

**Table 4. Living collections of fruit genetic resources held by different institutions in Malaysia.**[1]

| INSTITUTIONS | LOCATIONS | NUMBER OF SPECIES | NUMBER OF ACCESSIONS |
|---|---|---|---|
| DOA, P. Malaysia | Serdang<br>Taman Pertanian, Bkt Cahaya Seri Alam<br>Taman Pertanian, Indera Mahkota<br>Ulu Paka | 54 | 1000 |
| DOA, Sabah | Kundasang[2]<br>Tenom<br>Ulu Dusun (also *in-situ*) | 95 | 418 |
| DOA, Sarawak | Semongok<br>Taman Pertanian, Sg., Sebiew<br>Tarat | 38 | 310 |
| FRC, Sabah | Sepilok (*in-situ*) | 14 | 133 |
| FRIM | Pasoh (*in-situ*)<br>Kepong | 54 | 200 |
| MARDI | Bkt Tangga<br>Cameron Highlands[2]<br>Jeram Pasu<br>Jerangau<br>Kemaman<br>K. Kangsar<br>Kluang<br>Pontian<br>Serdang | 100 | 2230[3] |
| UPM | Serdang | 36 | 239 |
| UM | Kuala Lumpur | 71 | 207 |
| TOTAL | | 154 | 4737 |

[1] Estimated figures; Wan Razali et al. (1993), Saw et al. (1991).
[2] Sub-tropical and temperate fruit collections.
[3] Not including accessions obtained through MARDI-IBPGR collection in 1984/85.

Lamb (1993), Wong (1993), Voon et al. (1992) and Serudin (1993).

**Fruit Arboreta**

More recently, there has been a strong surge of interest in the pursuit of agro-tourism, leading to establishment of a number of agricultural parks. A number of parks have also established fruit arboreta of some sort, ranging from a simple to well-planned ones. Presently, there are few fruit "arboreta" that have been established for more than twenty years. Fruit arboreta are now found in:

FRIM, Kepong, Selangor;
Agriculture Park, Bukit Seri Cahaya, Shah Alam, Selangor;
Agriculture Park, Sg. Sebiew, Bintulu, Sarawak;
Agricultural Research Centre, Tenom, Sabah;
Agricultural Research Centre, Ulu Dusun, Sabah. (Table 4)

**Potential Uses of Minor and Rare Fruits**

Many local popular fruits such as durian, rambutan, and cempedak now have selections that are more superior than their progenitors from the rainforests. The obscurity of the lesser-known indigenous fruit species is either because they are localized and little known outside or because superior genotypes have not been found such that they are rendered undesirable and therefore they become ignored totally. Furthermore, these materials are difficult to work with because of the undesirable characteristics such as seasonal, late and difficult to propagate.

It is apparent that there is a long list of indigenous fruits but the more familiar ones include:

| | |
|---|---|
| asam gelugur | *Garcinia atroviridis* |
| bacang | *Mangifera foetida* |
| binjai | *Mangifera caesia* |
| cerapu | *Garcinia prainiana* |
| jambu air | *Syzygium aqueum* |
| jambu bol | *Syzygium malaccense* |
| jambu mawar | *Syzygium jambos* |
| kelubi | *Salacca conferta* |
| kuini | *Mangifera odorata* |
| pulasan | *Nephelium ramboutan-ake* |
| rambai | *Baccaurea motleyana* |
| sentul | *Sandoricum koetjape* |
| sukun | *Artocarpus communis* |
| tampoi | *Baccaurea griffithii*. |

However, there is an increasing interest in planting of heretofore lesser important fruit types in specific parts of the country. These include jambu air, sukun and dokong (*Lansium domesticum*) in Peninsular Malaysia, salak (*Salacca edulis*) in Terengganu, tarap (*Artocarpus odoratissmus*) in Sabah, and isau (*Dimocarpus longan*) and dabai (*Canarium odontophyllum*) in Sarawak. With few exceptions, information on many of these lesser important fruit types are scanty.

Most of the indigenous fruit species have been assessed mainly from the timber-producing perspective, and their other uses particularly for breeding and improvement are still negligible (Hashim, 1987). These species can either be harnessed directly or indirectly to exploit their potentials, namely for the following purposes:

**Direct utilization**
(1) As new fruit trees.
(2) As multi-purpose trees.

**Indirect utilization**
(3) As rootstocks for specific purposes:
disease resistance;
tolerance to adverse environments;
dwarfing;
efficient uptake of nutrient; and
availability of seeds.
(4) As sources of germplasm for breeding and improvement:
desirable traits, and
pollenizer.

**Brief Descriptions of Potential Minor and Rare Fruits**

Many minor and rare fruits have potential in their own rights, and these are briefly described below.

**Sukun** (*Artocarpus communis*)

The breadfruit is well known in Polynesia of course, but it is believed to have been introduced there. It is a versatile crop, which is useful both as starchy vegetables and fruits. Two forms exist with the seedless form being the more desirable ones. The beautiful tree can be propagated by seed, producing the breadnut (*A. kemangsi*), or more commonly by root cuttings or suckers, producing the seedless form.

**Tarap** (*Artocarpus odoratissimus*)

Outside Borneo island, tarap is not

well-known, though in Philippines scattered trees of tarap can be found in the Southern islands. It appears to be confined to Sabah, Brunei and Sarawak with greatest diversity in the Brunei. Ripe fruits are light brown, weighing one to three kg and contain sixty to two hundred seeds. The stiff hairs give way to touch, but are sticky and gritty. The whole fruit is a fused berry with the seed attached to the central core. Each seed is covered with a sweet and juicy white pulp. The seed is edible and can be roasted or boiled. The taste of the seed is somewhat like chestnut. The white pulp can be fermented to organic vinegar.

Tarap is a hardy plant and thrives on the poorest soils, on rocky outcrop and even on peat. It grows rapidly and into huge tree and once established, the tree grows aggressively to dominate the canopy with the broad huge leaves.

**Dabai** (*Canarium odontophyllum*)

Locally found in Sarawak and known as "dabai", this so-called tropical olive belongs to the family Burseraceae, and is a relative of the pili nut of the Philippines or the Chinese olive. The tree can attain great heights up to twenty-one metres and is seasonal in fruiting from August to December. The fruit, with persistent calyx present below, is dark purple and ellipsoidal with rind enclosing the triangular stony seed. It has high fat content and is eaten after the fruit is steeped in boiling water for ten to fifteen minutes. Adding fine salt enhances the taste of the rind. The fruit normally has a short shelf-life, often becoming soft and wrinkle at ambient temperatures after three days.

**Isau** (*Dimocarpus longan spp. malesianus*)

Belonging to the Sapindaceae family, this attractive species is a relative of the most commonly cultivated longan. Having similar sweetness and nearly as thick aril, the fruit can be distinguished from longan by its warty skin. The species is reported to have between thirty to forty different forms, and this gives a remarkable opportunity for making selection. In Sarawak, three major forms are found, namely the "isau," "kakus" and "sau." Among these three forms, the "isau" has the thickest aril and sweeter, but remain green when ripe, and the fruit bunch not compact. The "kakus" is widespread in Sarawak, while the other two forms are mainly confined along Rajang river and the valleys of the Bario Highlands.

**Kuini** (*Mangifera odorata*)

Like bacang, kuini is another species that also has a characteristic for good nutrient uptake and may prove valuable to use it as rootstock to increase the efficiency of Ca uptake. The species also has the potential to be used in processing for its juice.

**Pulasan** (*Nephelium ramboutan-ake*)

The species resembles closely the rambutan and is considered as one with very good potential. Unlike rambutan, the fruits have short and stubby spinterns. The edible part is the sarcotesta, which is similar to rambutan and has excellent fruit quality, that is the sarcotesta is thick, crunchy, juicy and sweet. A major problem is with propagating, because the success of budding is usually very low.

**Salak** (*Salacca edulis*)

Salak, known as the snake fruit, is native to Indonesia and Malaysia, and is widely cultivated in Indonesia. Belonging to the palm family, it has male and female flowers in separate palms. Male palms are required as pollenizer plants. The indigenous salak grown in Malaysia is of the species *Salacca glabrescens*.

The few existing salak plantings are mainly seed lines from the Balinese bisexual types. Whilst quality is satisfactory, the amount of production is not and the fruiting season (January and February) is relatively short.

**Jambu air** (*Syzygium aqeum*)

The wax apple belongs to the Myrtaceae family, which comprises about 1,000 species, the most famous being the clove tree. The fruits, bell-shaped with a wide apex and a narrow base, are eaten fresh or dipped in a mixture of salt, sugar and chili. It is very popular in Taiwan, and there are also now superior varieties being planted in Thailand, Indonesia, Philippines and Malaysia.

**Bidara** (*Zizyphus mauritiana*)

The plant is planted quite a bit in Taiwan and Thailand. A number of sweeter and more crunchy varieties are now seen in the markets. Some commercial plantings are already taking place in Malaysia. Besides eating fresh, the fruits can also be turned into pickles.

**Future Scenario of the Fruit Industry**

The small and inefficient economy of scale of present holdings or "dusuns" is hardly the answer to acceleration of the fruit industry. Rather, commercial orchards which are more efficient in utilization of resources, will be seen as the backbone of the industry in future. There are noticeable changes from the traditional "dusun" style of fruit cultivation consisting of mixed fruits of small acreages to profit-oriented, commercial scale farms of monocrops. More private agencies, previously involved with only plantation crops have also stepped in to cultivate fruits. Thus, in formulating the overall fruit development program, one of the strategies is to encourage large scale commercial cultivation of selected fruits.

However, making profits out of growing fruits is not as easy as it may sound. In fact, there is already growing frustration faced by several commercial growers who are cultivating fruits but so far have not made profits. Amidst the rapid progress of the fruit industry, is the need to have strong and sustained research and development support.

**Fruit Research**

The overall objective of the fruit research is to develop appropriate technologies for increasing the productivity and quality of local fruits, enabling them to meet domestic and export demand as well as increasing the income of the producers. In future, more emphasis will be given to fruit types for processing and other downstreaming activities.

In the past, MARDI identified and gave priority to 16 fruit types for research. These will now be reduced to about half the number to ensure more intensified research. At the same time, a large scale field research is also conducted to test appropriate technology package for commercial production, processing and marketing of selected fruits.

**Conclusion**

It is obvious that markets, both domestic and overseas, possess great potential for expansion and further exploitation of tropical fruits. However, the present industry is still far from being sufficiently poised to tap this potential fully, given the current constraints. At present, pineapple, durian, starfruit, papaya, watermelon and banana are the main fruit types in the industry, many of them being non-seasonal. If tropical fruits are given the push through concerted efforts, and given more emphasis on processing and downstreaming activities, they can be positioned to become another important remunerative crop in the Malaysian agriculture.

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# Global Marketing of Malaysian Fruits

**Mohamad bin Osman, Basic Research Div., MARDI, Serdang**
**Zahari Radi, Techno-Economic Div., MARDI, Serdang**
**Othman Yaacob, Faculty of Agriculture, Universiti Pertanian Malaysia**

**Introduction**

In Malaysia, as it is in some parts of Southeast Asia, except Thailand and the Philippines, fruits are still not commercially produced in the big way as the oil palm, rubber, cocoa or rice. For the bulk of it, fruit cultivation is a side-line activity associated with rural living. For most of the trees producing seasonal fruits, they are not planted by the present generation, were are inherited from their fathers, who in turn inherited them from their grandfathers.

The bulk of the fruit industry is still characterized as a small holder enterprise involving 180,000 hectares of widely scattered holdings with mean farm size of one to two hectares. The cultivation of fruits by smallholders is unorganized, and the portion of the farm actually planted with fruits is generally low, with majority of the cases less than 50%, and usually integrated with other crops. Before the National Agriculture Policy (NAP) was launched in 1984, there were no specific policies for the development of the fruit industry. The early ad hoc programmes such as the Agricultural Inputs and Diversification Scheme (AIDS) did not have significant impact on the industry for more than twenty years.

Despite all these, the growth of the fruit industry is expected to increase at a strong pace in the coming years. The shift from uneconomical smallholders of mixed orchards to efficient commercial farms will be more evident. Currently, the fruit industry is being looked upon as an alternative source of output growth in agriculture, aimed at creating and expanding the local and export markets. In short, the fruit industry will be geared towards commercial production with greater emphasis on processing and other downstream activities of selected fruit types.

**Contribution to the National Economy**

The contribution of fruits to GDP increased since 1985 from RM922 million to RM1,700 million in 1990, a rise from 1.7% to 2.1% (Table 1). In the same period, the fruit areas in Peninsular Malaysia climbed from 119,000 to 181,000 hectares, resulting in a production increase from 842,000 metric tons to 1,102,000 tons. The major increase were led by durian, cempedak, jackfruit, starfruit, papaya and watermelon.

The potential for growth of the fruit industry can be expected in three main areas: (1) the domestic fresh fruit demand; (2) export demand for exotic tropical fruits; and (3) processing. Papaya and starfruit are already being exported fresh and have good potential for further growth. Fruits such as durian, watermelon, citrus, rambutan and banana have strong domestic demand. And pineapple, passion fruit, and pink guava are already known for their processing.

**Local Consumption**

The consumption of local fruits per household is found to have increased from year to year. A study conducted by FAMA estimated that the per capita consumption comprising 22 local fruit types has increased from 23.5 kg in 1985 to 27.7 kg in 1991 (Table 2). In the study, it was found that the consumption by the households, institutions and industries increased from 538,000 tons in 1989 to 689,000 tons in 1992. Among the 22 fruits, durian, watermelon, citrus, banana, papaya, rambutan and pineapple have strong domestic demand. This upward trend is expected to continue because more consumers are aware of the high nutritional value of the local fruits, and more fruit types and varieties becoming available in the retail markets. This trend is also influenced by the growing affluence of the population and the increase in standards of living, particularly in the urban centers.

On the other hand, the per capita consumption of four types of temperate fruits (grapes, apples, pear and oranges) have remained at about the same level. With slight decline from 3.98 kg in 1988 to 3.26 in 1991. Figure 1 gives the comparison between the per capita consumption of tropical fruits versus that of temperate fruits in the country.

**Local Marketing**

In spite of the difficulties faced by the once-neglected industry, fruits such as durian always

**Table 1. Selected indicators of progress in the Malaysian fruit industry, 1985-1990.**

| | 1985 | 1990 |
|---|---|---|
| Contribution to GNP Values ($ million) | 921.8 | 1,699.7 |
| % contribution | 1.7 | 2.1 |
| Export | | |
| Fresh fruit (mt) | 116,841 | 209,000.0 |
| Value ($ million) | 72.3 | 138.7 |
| Processed fruit value ($ million) | 66.4 | 85.3 |
| Fruit hectarage | 119,024 | 181,793.0 |

Source: Economic Report 1991/1992, Finance Ministry, Malaysia.

**Table 2. Per capita consumption (kg/person/year) by fruit types, 1982-1991.**

| Fruit types | 1982 | 1985 | 1988 | 1991 |
|---|---|---|---|---|
| Starfruit | - | 0.17 | 0.39 | 0.54 |
| Papaya | 1.69 | 2.06 | 2.45 | 2.23 |
| Cempedak | 0.02 | 0.09 | 0.60 | 0.67 |
| Ciku | 0.10 | 0.15 | 0.19 | 0.14 |
| Duku langsat | 0.93 | 0.71 | 0.82 | 0.81 |
| Durian | 4.33 | 4.78 | 4.20 | 4.81 |
| Guava | - | - | 0.43 | 0.59 |
| Pomelo | 0.14 | 0.12 | 0.14 | 0.13 |
| Mangosteen | 1.00 | 0.46 | 0.44 | 0.31 |
| Mango | 1.09 | 1.25 | 0.45 | 0.88 |
| Nangka | 0.49 | 0.22 | 0.34 | 0.23 |
| Pineapple(Mauritius) | 1.84 | 1.58 | 1.33 | 1.14 |
| Pineapple(Sarawak) | 0.24 | 0.41 | 0.52 | 0.52 |
| Banana(Berangan) | 0.33 | 0.38 | 0.65 | 0.48 |
| Banana(Mas) | 1.29 | 2.21 | 2.97 | 2.71 |
| Banana(Embun) | 0.37 | 0.44 | 0.37 | 0.39 |
| Banana(Raja) | 0.27 | 0.30 | 0.25 | 0.23 |
| Banana(Rastali) | 1.20 | 1.08 | 0.95 | 0.71 |
| Banana(Nangka) | 0.61 | 0.66 | 0.62 | 0.63 |
| Rambutan | 1.72 | 1.78 | 1.79 | 1.96 |
| Mandarins | 1.33 | 2.32 | 2.81 | 3.01 |
| Watermelon | 2.13 | 2.30 | 2.77 | 4.54 |
| Total | 21.20 | 23.53 | 25.55 | 27.74 |

Source: FAMA

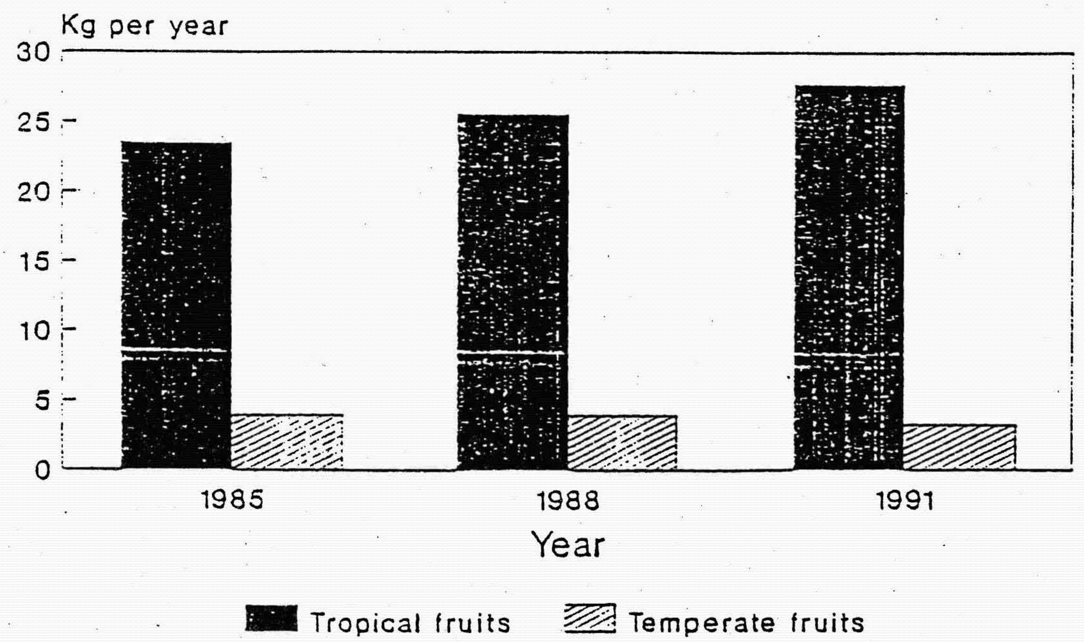


**Figure 1. Per capita consumption of fruits in Malaysia.**

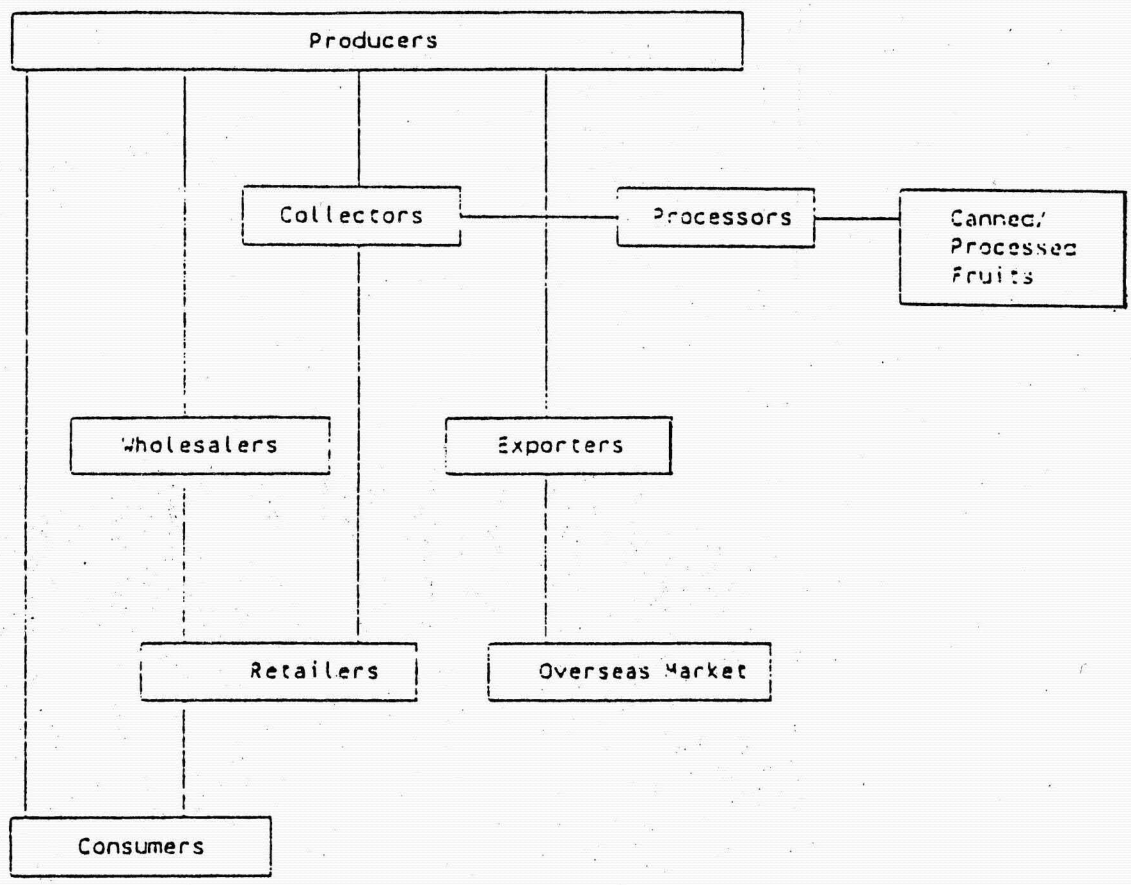


**Figure 2. Marketing system for fresh fruits in Malaysia.**

finds ready markets. Marketing starts at the farm level where the fruit collectors play a very important role in bringing them out of the holdings from the rural areas or deep from the interior. The collectors in turn sell to the wholesalers from whom retailers obtain their supplies. The retailers bring them to various marketing outlets (Figure 2). In a survey conducted by MARDI and UPM, about 55.4% of the farmers were reported selling to collectors, with 31.9% of them selling directly to consumers while 4.7% contracted or leased out their holdings and orchards. Taking the system as a whole, the wholesalers together with the collectors play a dominant role in the marketing system of fruits. It is not uncommon for the collectors and wholesalers to perform more than one role in the marketing of fruits such as the collector-cum-retailer or collector-cum-wholesaler or wholesaler-cum-retailer. The wholesaler's role is particularly critical in the inter-state movement of fruits. At the retail level, the traditional retailers such as those having stores in markets dominate the marketing of fruits.

The Kuala Lumpur/Petaling Jaya center is the largest market center for fruits in Peninsular Malaysia. In all, over 6,800 tons of local fruits are handled monthly. From the wholesale market, fruits are distributed daily to major retail markets in Kuala Lumpur, Petaling Jaya, Shah Alam and Klang - the affluent Klang Valley - as well as to other states. Other urban centers for fruit distribution are Penang, with about 1,000 tons per day, Ipoh handling over 30 tons per day, and Johor Bahru with over 10 tons per day. During the peak seasons, seasonal fruits such as durian and rambutan are also channelled through these centers.

Recent trend shows that more growers are now able to sell directly to consumers or through local traders at roadside stalls near the production areas. Competition at the retail level is keen as there is a trend towards wider spread of retailing through night markets and supermarkets. Farmers's markets or *pasar tani* are a recent development in urban areas and serve as important direct outlets.

Another recent feature in the local marketing scenario is the willingness of large supermarkets to sell them in their outlets when the fruits are in season. The proper displays on the supermarket shelves, with of course appropriate price tags, appeal to foreign visitors as well as the well-to-do urban populace. Supermarket chains - the three big ones being Hankyu Jaya, Parkson Grand and the Cold Storage - obtain their regular supplies from known suppliers. At the moment, three suppliers - the Pita Trading, the Master Fresh and the Crystal Fruit - supply fresh fruits to supermarket chains in major cities in the country. These suppliers are responsible for gathering fresh fruits from all over the country. Few growers become contractors for these supplies. These are, therefore, new opportunities for growers to produce good quality fruits for local markets.

**International Fruit Trade**

Malaysia is probably close to becoming a net exporter of fruits. In 1992, total exports of fruits, both fresh and processed) were valued at RM255.4 million while the total fruit imports were valued at RM234.0 million (Tables 3 and 4). The main fruits exported were pineapple (32.8%), durian (22.2%), starfruit (9.6%), papaya (9.6%), watermelon (9.1%) and banana (5.4%), and together these fruits contributed 89% of the total fruit export value.

In 1992, Malaysia imported 145,000 metric tons of temperate fruits (fresh and processed) into the country. These imports were dominated by oranges (including mandarins) which amounted to 35.6%, and apples which constituted 23.7% of total import value. Others included grapes (9.7%), pears (9.5%), dates, dried grapes and plum. Most of the fruits were from the United States of America (USA) and Australia, which together accounted for over 60% of all temperate fruits imported into Malaysia.

Besides temperate fruits, the country also imports tropical fruits. The main tropical fruits imported into Malaysia were durians, and mangoes, mainly from Thailand, with imports valued at RM16.4 million in 1992.

**Export of Fresh Fruit**

Malaysia has shown an increasing trend in the exports of fresh fruits in recent years (Table 5). In 1982, the total export value was RM28.1 million and this climbed to RM151.1 million in 1992. The breakdown on the fresh fruits exported were durian (31%), watermelon (20.3%), papaya (16.4%), starfruit (16.2%), banana (6.2%) and pineapple (2.1%) (Table 6).

Fruits registering significant increase in exports in recent years included starfruit, papaya and watermelon. Mangosteen has also came up strong in the export value, increasing from less

**Table 3. Import of fresh fruits to Malaysia, 1980-1992.**

| Year | Quantity (m.t.) | Value (RM'000) |
|---|---|---|
| 1980 | 58,773 | 85,175 |
| 1981 | 68,156 | 112,251 |
| 1982 | 64,039 | 117,735 |
| 1983 | 83,624 | 146,000 |
| 1984 | 84,036 | 165,529 |
| 1985 | 83,428 | 168,725 |
| 1986 | 76,168 | 159,039 |
| 1987 | 90,582 | 165,190 |
| 1988 | 84,295 | 160,973 |
| 1989 | 84,750 | 165,644 |
| 1990 | 110,727 | 204,200 |
| 1991 | 80,245 | 164,593 |
| 1992 | 126,877 | 192,406 |

Source : External Trade Statistics, Malaysia

**Table 4. Import of processed fruits to Malaysia, 1980-1992.**

| Year | Value (c.i.f. RM) |
|---|---|
| 1982 | 57,093,000 |
| 1983 | 58,776,000 |
| 1984 | 52,198,000 |
| 1985 | 45,352,000 |
| 1986 | 38,136,000 |
| 1987 | 33,361,000 |
| 1988 | 32,994,490 |
| 1989 | 35,727,100 |
| 1990 | 33,267,400 |
| 1991 | 36,730,000 |
| 1992 | 41,626,200 |

Source : External Trade Statistics, Malaysia

**Table 5. Export of fresh fruits from Malaysia, 1981-1992.**

| Year | Quantity (m.t.) | Value (RM'000) |
|---|---|---|
| 1981 | 77,320 | 26,391 |
| 1982 | 105,900 | 28,054 |
| 1983 | 77,600 | 31,518 |
| 1984 | 95,464 | 33,529 |
| 1985 | 112,598 | 70,069 |
| 1986 | 109,240 | 58,884 |
| 1987 | 141,587 | 79,163 |
| 1988 | 157,762 | 83,489 |
| 1989 | 192,590 | 126,718 |
| 1990 | 203,108 | 149,228 |
| 1991 | 173,303 | 159,829 |
| 1992 | 185,886 | 151,147 |

Source : External Trade Statistics, Malaysia

**Table 6. Exports of fresh fruits from Malaysia, 1988-1992.**

| | 1988 | | 1989 | | 1990 | | 1991 | | 1992 | | Percent (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tons | RM'000 | Tons | RM'000 | Tons | RM'000 | Tons | RM'000 | Tons | RM'000 | |
| Durian | 19,389 | 34,683 | 36,970 | 42,925 | 27,330 | 45,683 | 34,903 | 54,981 | 26,876 | 44,589 | 31.0 |
| Watermelon | 25,116 | 9,128 | 36,124 | 15,347 | 52,316 | 25,514 | 46,118 | 22,361 | 64,580 | 29,264 | 20.3 |
| Papaya | 23,736 | 12,057 | 23,217 | 18,002 | 31,444 | 21,003 | 22,772 | 23,348 | 23,225 | 23,630 | 16.4 |
| Starfruit | 6,778 | 14,949 | 11,465 | 20,613 | 11,324 | 22,439 | 7,901 | 23,918 | 11,056 | 23,372 | 16.2 |
| Banana | 28,489 | 7,233 | 25,407 | 7,549 | 33,732 | 12,104 | 22,622 | 13,301 | 20,701 | 8,978 | 6.2 |
| Pineapple | 13,227 | 2,038 | 18,446 | 2,939 | 23,341 | 3,558 | 18,370 | 2,903 | 19,039 | 3,086 | 2.1 |
| Others | 7,212 | 4,877 | 22,986 | 13,373 | 17,278 | 12,053 | 13,832 | 11,717 | 10,999 | 11,128 | 7.3 |
| | 124,447 | 84,970 | 174,615 | 121,248 | 196,765 | 142,404 | 167,018 | 153,029 | 176,484 | 144,052 | 100.0 |

than RM0.5 million in 1984 to more than RM2.9 million in 1992. Similar trend was observed recently for the Cavendish banana.

**Exports of Processed Fruit**

Other than fresh fruits, processed fruits have also contributed to exports. Since the early years, pineapple has been the main crop for this. However, recently other fruit types have also gone into processing such as pink guava, passion fruit, starfruit, soursop and calamondin. Overall, the total export value of processed fruits has also shown an increasing trend, from RM67.2 million in 1982 to RM104.3 million in 1992 with canned pineapple contributing 77.8% of the value (Table 7).

**Market Destinations**

Overall, Singapore is still the single most important export market for Malaysian fresh fruits, although its share of the market has seen some gradual decline over the recent years. In 1992, Singapore's market accounted for 59.8% of the total export while Hong Kong (21.9%) was a distant second. Besides importing fruits for its domestic consumption, Singapore being an entrepot is a unique market because it also re-exports the fruits imported from Malaysia and other countries to various fruit markets worldwide. The EEC countries imported about 12.2% of the export, and these countries appear to have an increasingly good potential market for the tropical fruits (Table 8).

In order to expand the export market for the Malaysian fruits, market opening must be made beyond the two traditional markets, i.e., Singapore and Hong Kong.

For Malaysia, the EEC countries are considered as a newly found market for our starfruit. The promotions carried out by Federal Agriculture Marketing Authority (FAMA) with the collaboration of the private sector, exporters and various trade missions have been particularly successful in developing a big market for our starfruits.

The Middle East is another good market for

**Table 7. Export of processed fruits from Malaysia, 1982-1992.**

| Year | Value (RM'000) | Canned Pineapple | |
|---|---|---|---|
| | | Value (RM'000) | % |
| 1982 | 67,222 | 53,256 | 79.2 |
| 1983 | 70,491 | 51,993 | 73.8 |
| 1984 | 78,461 | 54,411 | 69.3 |
| 1985 | 66,420 | 54,566 | 82.1 |
| 1986 | 69,113 | 55,961 | 82.1 |
| 1987 | 73,710 | 49,926 | 67.7 |
| 1988 | 78,157 | 57,614 | 73.7 |
| 1989 | 77,622 | 61,107 | 78.7 |
| 1990 | 96,382 | 78,398 | 81.3 |
| 1991 | 115,315 | 94,018 | 81.5 |
| 1992 | 104,316 | 81,159 | 77.8 |

Source : External Trade Statistics, Malaysia

**Table 8. Fruit exports from Malaysia by market destination, 1988-1992.**

| Market Destinations | 1988 | | 1989 | | 1990 | | 1991 | | 1992 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | RM'000 | Percent (%) | RM'000 | Percent (%) | RM'000 (%) | Percent (%) | RM'000 | Percent (%) | RM'000 | Percent (%) |
| Singapore | 61,385 | 72.2 | 80,944 | 668 | 91,338 | 64.1 | 93,905 | 61.4 | 86,090 | 59.8 |
| Hong Kong | 11,855 | 13.9 | 21,787 | 18.0 | 29,730 | 20.9 | 30,786 | 20.1 | 31,526 | 21.9 |
| Europe | 9,895 | 11.6 | 13,186 | 10.9 | 15,567 | 10.9 | 20,069 | 13.1 | 17,518 | 12.2 |
| Middle East | 30 | 0.0 | 438 | 0.4 | 352 | 0.2 | 841 | 0.5 | 846 | 0.6 |
| Far East - Japan | 148 | 0.2 | 7 | 0.0 | 1,640 | 1.2 | 1,894 | 1.2 | 533 | 0.4 |
| - Taiwan | 268 | 0.3 | 295 | 0.2 | 220 | 0.2 | 268 | 0.2 | 2,574 | 1.8 |
| Thailand | 23 | 0.0 | 1,082 | 0.9 | 1,374 | 1.0 | 730 | 0.5 | 3,183 | 2.2 |
| Other countries | 1,566 | 1.8 | 13,516 | 2.9 | 2,184 | 1.5 | 4,536 | 3.0 | 1,778 | 1.1 |

**Table 9. Retail prices (RM/kg) of selected fruits in Malaysia compared with wholesale prices in several markets in Europe in 1992.**

| Fruit Type | Local Retail Price | Wholesale Prices in Belgium | France | Germany | U.K. | Netherland |
|---|---|---|---|---|---|---|
| Starfruit | 2.44 | 9.06 | 12.62 | 8.72 | 9.47 | 7.92 |
| Papaya | 1.02 | 6.78 | 8.21 | 6.45 | 8.23 | 5.70 |
| Rambutan | 2.49 | 14.22 | 15.59 | 14.26 | 19.10 | 12.00 |
| Mango | 4.13 | 4.16 | 5.46 | 4.68 | 5.19 | 4.34 |
| Guava | 1.63 | 10.14 | 11.59 | 8.80 | - | 10.40 |
| Mangosteen | 3.09 | 14.75 | 15.14 | 14.41 | 18.31 | 12.00 |

Sources: FAMA & Market News Service, ITC, Geneva

the tropical fruits, but its market expansion has been meagre in spite of the various promotions carried out recently. Japan, Taiwan and more recently China, are potentially "big" markets for tropical fruits, but penetration into these lucrative markets have been very difficult (non-tariff barriers).

**Market Prices**

In consonance with the increasing per capita income and consumption of tropical fruits, the domestic fruit market also experiences an increasing trend in the retail prices of selected fruits. For example, in 1992 there was 4.5% to 55.2% increase in prices for these fruits as compared with 1991.

Overall, the export markets appear to be more lucrative for some. Table 9 gives a comparison between the 1992's retail prices of some selected fruits in the local market and the wholesale prices in several markets in Europe. These prices look attractive, but in order to make profits, the wholesale prices must offset the minimum air freight cost of RM4.60 per kg fruit, besides other costs.

**Trade Specific Fruit Types:**

**Pineapple**

Canned pineapple contributed 77.8% of the total export of the processed fruits, and they are mainly in the form of slices and cubes. In 1992, the major markets for canned pineapple were Japan (24.5%), U.K. (10.0%), USA (8.4%), UAE (7.4%), Singapore (6.8%), Netherland (5.6%) and Saudi Arabia (4.8%). To date, there is very little production of the pineapple juices. Among the competitors in the region are countries like Thailand and the Philippines.

**Durian**

In Malaysia, durian is the top fresh fruit export. Out of the total production of 250,000 tons, more than 30,000 tons are exported mainly to Singapore (92.7% in 1992). Over the last five years, exports of durian have exceeded RM40 million annually. Although Thailand is a competitor in the strict sense, its durian production really complements Malaysia in the marketing of the fruits. Thailand is well-known for its durian, but its durians are of different types as produced in Malaysia, resulting in different consumer preferences. Furthermore, the durian

**Table 10. Postharvest quarantine requirements.**

| Treatment | Fruit type | Target markets | Recommendation |
|---|---|---|---|
| Vapour heat treatment (VHT) | Mango, papaya | Japan, USA, Australia, New Zealand | 46.5°C at 50% RH for 20 minutes |
| Cold treatment | Starfruit, mangosteen | Japan, USA, Australia, New Zealand | 2°C for 1 week |
| Fumigation | Starfruit | Japan, USA, Australia, New Zealand | 24 $gm/cm^3$ |
| Gamma irradiation | Starfruit, papaya | Japan, USA, Australia, New Zealand | 150 Gy |

seasons generally do not overlap very much with those in Malaysia; therefore extending the availability of the fruits in the year.

Presently, the development of cryogenic preservation has been seen as an innovative handling technology which can help extend the shelf life of durians as well as boost the prospects for export beyond the traditional markets.

**Starfruit**

The starfruit has already commanded a small but important niche in the international market since the late 1980's. The export value of starfruit has increased from RM14.9 million in 1988 to RM 23.4 million in 1992. And the major markets for starfruit were Europe (34.8%), Hong Kong (43.2%) and Singapore (19.5%). For Europe, the main variety exported is B10. Recently, on the production side, exports of the starfruit have been slightly hampered because of its the labour-intensive requirements. Efforts are still briskly underway to promote consumers in Europe to "eat" more of the fruits. At the present moment, much of the starfruit is used for garnishings, in salad and others, and really very little consumed.

Canada is now emerging as another new market for our starfruits. And in Europe, our competitors are from Israel and Brazil, but in future Australia may also be in the picture.

**Papaya**

For papaya, the Eksotika variety released by MARDI in 1987 was a tremendous success. In 1991, MARDI released another variety, a hybrid named Eksotika II, which has better yield and fruit cosmetics, and also keeps better than its predecessor. Papaya export was boosted up to a four-fold increase to RM23.6 million in 1992 compared to 1987. And the major markets of papaya were Singapore (81.1%) and Hong Kong (18.1%), and little in Europe. Presently, the production has not yet come back to its previous peak level since the scare of the papaya ringspot virus is still abound. In fact, the production areas have shifted from Johor to other states in the north, particularly in Perak.

Most of the papaya producing countries in the region are besieged with the ringspot virus, and this situation will probably keep the current production level at bay for a while.

**Watermelon**

Exports of watermelon have increased significantly since the late 1980's, and increased by about three-fold to RM29.3 million in 1992 compared to 1988. In 1992, the major markets were Singapore (82.8%) and Hong Kong (13.1%), and some to Taiwan and Thailand. China is expected to be a strong competitor in future.

**Banana**

Exports of banana have picked up since early 1990's when several big commercial farms began producing and exporting Cavendish and Berangan bananas. Local consumption of these bananas also have increased. Besides Singapore, the major markets for these bananas are United Kingdom and Japan. For Malaysia, the strong competitors are the Philippines and Thailand.

**Mangosteen**

The export of mangosteen out of Thailand and Malaysia is something quite recent. In 1989, Thailand exported to Hong Kong 350 tons of fresh fruits worth about RM390,000 and 30 tons of frozen mangosteen worth RM31,000. The other importing countries were Europe and Canada.

In 1988, the export from Malaysia was RM460,000 and it jumped six-fold increase to RM2.9 million in 1992. It is projected that the export of mangosteen from these two countries will continue to increase because of its strong promotion as well as good potential in the Japanese market.

**Rambutan**

In 1986, Malaysia and Thailand exported their rambutan worth RM750,000, while in the other producing countries, production was mainly for the domestic market. Malaysia exported its fresh rambutan mainly to Singapore (88.9% in 1992), while Thailand exported fresh and canned rambutan to Asian and European countries. Processed rambutan products of Thailand fetched more than 10 times the value of fresh rambutan.

**Processing Fruits**

For many years, the technologies developed for the fruit industry were basically geared for domestic consumption and for fresh. For the same reason, the export expansion also involved the fresh fruits with the exception of pineapple.

Although not without difficulties, the fruit industry also managed to promote the development of several fruit types for processing. Notable among these fruits are pink guava and calamondin, which are now commercially produced in Johor; and passion fruit, which is grown by farmers in Sabah. Apart from these fruit types, soursop and starfruit are also now being developed for processing. Taiwan has a limited production area for starfruit, but has successfully commercialized the production of starfruit juices.

**Contraints to Global Marketing:**

**Quarantine Restrictions to Exports**

The present export markets for starfruit, durian, papaya and watermelon are mainly to Singapore and Hong Kong. And only relatively small quantities of starfruit and papaya Eksotika reach the European markets. All these markets do not have any pest quarantine restrictions.

As mentioned earlier, there are potential markets in Japan, USA, Australia and New Zealand for tropical fruits. However, these countries have very stringent pest quarantine regulations, especially against the fruit flies. Imported fruits must be pest-free. In order to achieve this, certain postharvest disinfestation protocols specified by these countries must be followed. The usual methods are vapour heat treatment (VHT), irradiation, fumigation and cold treatment. These treatments are found to be not suitable for some fruits because they affect the quality in terms of color and flavour, while others may only be applicable under certain circumstances or in certain countries only. This is really a setback to the development of the fruit industry. Post harvest disinfestation research is now being actively pursued for fruits which have good export potential, namely mango, starfruit, papaya and mangosteen (Table 10).

**Storage Life of Tropical Fruits**

The export of fresh fruits is, to a large extent, hampered by the relatively short storage life of the fruits. There are only very few of them that can be kept in storage for more than three weeks (Figure 3). These fruits can reach the market destinations quickly by air; however, the cost of air freight is usually prohibitive. The exporters have very little choice except to send the fruits by sea which takes much longer time, and run the risk of delivering fruits with poor quality on arrival. For example, to ship fruits to Europe, it will probably take about 6 weeks, which surpasses the storage life of most tropical fruits.

At present, limited technology on harvesting practices, postharvest handling, storage and packaging of fruits have resulted in substantial losses throughout the handling chain, from the farm to the distribution outlets. Intensified research on efficient postharvest handling is, therefore, more critical for fruits meant for export, especially to facilitate sea transportation.

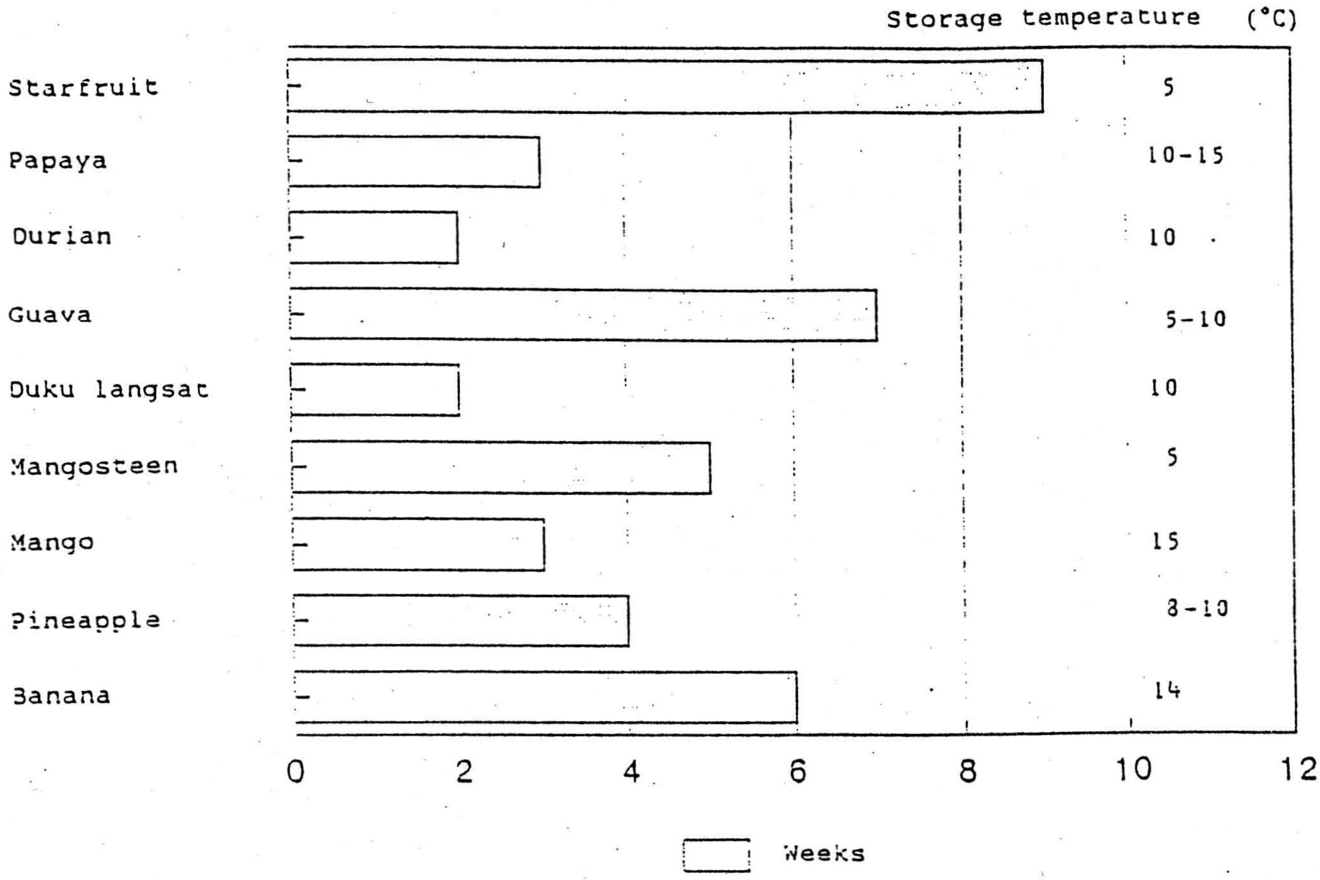


**Figure 3. Storage life of tropical fruits.**

**Competition in Air and Cargo Space**

To some extent, the export of fruits from Malaysia has been initially expedited via air freight. However, further increase in their export has been hampered by the limited air cargo space and the unfavourable freight charges. At present, the volume of air cargo under special rates (Specific Commodity Rate) allotted for exporters is only 16 metric tons per week. Apart from the scarcity of cargo space, the other problem is the air cargo rate itself. The SCR freight rates are still considered high, rendering the prices to be less competitive in markets of the importing countries. The non-SCR cargo is readily available, but the rates can be three four times higher. In fact, very few exporters now send their fruits by air freight because of the prohibitive charges and other handling problems, and mostly have resorted to sea transportation.

**Conclusion**

The prospects for the expansion of the fruit industry in Malaysia appear bright due to the expected increase in domestic consumption of both fresh and processed fruits, and the expected increase in the export markets stemming from increasing world demand in tropical fruits. Among the fruits that have contributed to the country's fresh exports are durian, starfruit, papaya, banana and watermelon.

Other than in the fresh form, Malaysian fruits also have good potential for the production of fruit juices whose market is ever expanding in Europe and in the Middle East. Besides pineapple, there are already few fruit types that have shown very good potential for processing such as pink guava and soursop. The global trade in fruit juices is worth billions, and Malaysia's share in this trade is estimated to be less than 1%. Malaysia has yet to make inroads in this fast expanding international market.

Although the export markets for fresh and processed fruits are not yet fully exploited, sustaining the present markets is no easy task. The traditional markets should not be taken for granted. It is, therefore, important for the country not to focus only on the market development but also on the product development, as well as the development of the fruit industry itself, especially in boosting commercial production of fruits with good export potential. Efforts should be made to encourage the participation of foreign investors in the commercial production of fruits in Malaysia so as to capture the established overseas markets.

**Acknowledgements**

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# Benefits of Generic Promotion

**Tom and Ann Thacker**
**The Thacker Group**

**The Thacker Group Agency Profile**

We are a public relations firm specializing in food and flowers. Our offices are in Sacramento, Kona, San Francisco and Houston. We work with commondity boards such as California wild rice, Texas peanuts, Texas onions, pimientos, California tree fruits, and California cantaloupe. We publicize some of the PBS cooking shows, and work with branded products such as Sunkist Growers, McCormick Spices, Campbell Soup and Del Monte Foods. In Hawaii, we have done projects work with DBEDT, HVB, and DOA. We are now executing a start-up public relations program for the Hawaii Tropical Flower Council.

**Exposure = Awareness = Sales**

The exposure = awareness = sales formula has been true for decades and is still true today. Unless you expose your products within the marketplace and educate the end-user about ways to prepare and eat them, increased sales will not happen. The challenge is to create demand by making your products top-of-mind.

In the case of some of the more unusual tropical fruits that are grown here, consumers who are unfamiliar with them do not know whether to eat them, bathe with them or shoot them. Even in Honolulu last year, we saw starfruit carefully cut and displayed in the produce section. But even the produce manager did not get it! The product had been sliced lengthwise in a slice of cantaloupe. Education! It is a big, big job. We are here today to show you some effective ways that you can educate consumers and retailers.

**Media Tour Title Slide**

Taking your message to the masses through television, radio and print:

"This stuff is worth $50,000 a minute on prime time TV, so eat it!"

We are executing a media tour for Sunkist growers. Within the last six months we have been to fifty-eight cities, conducted over one-hundred and thirty interviews, which have resulted in more than $1.5 million dollars of editorial exposure. The cost to Sunkist is just over $200,000. Another example is using National Cable for Sam Choy products. The radio is a great broadcasting medium. Don't forget the print, a media tour is an effective way to get your message out there.

**ROP Title Slide**

A ROP Title Slide - It's a full color, full page, food story that we prepare for the food editor on behalf of our clients. There's a method called the three-way that we did with California wild rice, California cut flowers, and artichokes. It's in ninety-seven papers, thirty-one states, and an eight million readership. Plus, the ad value is at $215,000, but the total cost to each client is only $12,500!

With California wild rice, we did a four-way. This included a release to weekly and suburban newspapers across the nation. The Pecan Bread, which was just released in May, already has appeared in one-thousand three-hundred newspapers in thirty-eight states. If we were to purchase this same amount of space through the paper, it would have cost the pecan board $300,000. Instead, the actual cost was about $8,000, including the photography. Clips are received and widespread, coast-to-coast coverage is the result.

**New York Magazine Editor Tour**

It's the Big Apple and we go through a collage of magazines such as Family Circle, McCalls, Good Housekeeping, and Woman's Day. Then we got the crew networking in various offices simultaneously: Ann in the office of Country Living and Redbook; Tom went to Philomena Corradeno; Mary in front of Good Housekeeping with Mildred Ying, the Good Housekeeping Food Editor.

In Sunset magazine, we had a salmon placement. It was two pages of editorial coverage, a $86,000 value if paid for as advertising. Then if you multiply that by three for the editorial value, it's worth more than $258,000. Hold up Sunset and talk about wild rice placement as a result of harvest tour, luncheon and personal relationship with editors.

**Food Photography**

Photography speaks for itself as we used it for: Wild Rice; California Swordfish; Pecan cake; and

Pecan pie. A three-way ROP with Texas peanut cookies, peanut butter, and Trail mix (Texas ID) by using Texas State recognition symbols such as the Texas flag and the Texas basket.

**First Day Promotion - Weather Casters**

First day of summer showing California summer fruit such as a plum basket. A Tree fruit on the news set for the Oakland weather caster. Catchy memory guides such as Giant Plums = Giants of San Francisco. Willard Scott in the Springtime for Texas Springsweet Onions using an onion box with a bright label. Images of the first day of fall connected to American Pecans. Keep videos of weather caster stuff for further promotion.

**Exposure = Awareness = Sales**

Back to exposure = awareness = sales with Sam Choy. We agree with Sam Choy - Hawaii, You are Okay! TTG Profile - We are ready when you are!

# Poster Abstracts

**Peach Palm for Palm Heart in Hawaii: Is it Worth Planting?**
**C. R. Clement, R. M. Manshardt, C. G. Cavaletto, J. DeFrank, K. Fleming, and J. Mood**

Peach palm was introduced by University of Hawaii in 1990 as a potential new crop to produce fresh heart of palm, a gourmet vegetable. After the first harvest cycle (twelve to sixteen months in the field) it is clear that: (1) the palm is well adapted to Hawaii at low elevations (below 1000 ft); (2) yields are similar to those reported from tropical America (900–1100 lb/ac); (3) precocity (measured as time from field planting to harvest) is more important than heart weight to determine yearly yield; (4) there is genetic variability for precocity; (5) acridity (itching in mouth or throat) is a minor problem (5–10% of plants); and (6) there are three edible portions, the heart (0.33–0.5 lb/shoot), the tender stem (0.75–1.0 lb/shoot), the tender leaves (0.1–0.3 lb/shoot). New ideas about plantation design, weed control, and fertilization will reduce labor requirements while enhancing yield. Germplasm that yields 90–95% spineless seedlings is available and spiny plants are easily removed in the nursery. Some upscale restaurants have expressed interest in the products at \$6–8/lb for heart and \$3–4/lb for stem. Each shoot could yield \$4–7 at harvest and, with 2000 plants/acre, an income of \$814,000 per acre is possible if the grower deals directly with the restauarant. If farmers deal directly and there is a favorable balance of supply and demand, the market can be kept orderly and both farmers and restaurants win. A rough cost-benefit model is presented and variables not included are identified so that the individual farmer can compute his/her own case. You decide: is it worth planting?

**Quality Evaluation of Fresh Peach Palm Heart (*Bactris gasipaes*).**
**C. G. Cavaletto, N. Y. Nagai, C. R. Clement, and R. M. Manshardt.**

Quality of fresh heart of palm from two progenies of the Benjamin Constant population of the Putumayo landrace was evaluated. Favorable sensory characteristics were: sweetness, tenderness, crispness, and moistness. Negative sensory characteristics found in some samples were: low levels of astringency and acridity. Sensory scores for astringency and acridity were significantly different ($p < 0.05$) between sections of the heart. Basal sections appear to be more acrid and astringent than the apical sections. Differences in acridity also exist between plants within a progeny ($p < 0.05$). Percent total soluble solids ranged from 3.0l to 6.6, but no pattern was apparent. Samples were also provided to chefs in upscale restaurants where they received favorable comments.

**Effect of Planting Density on Precocious Palm Heart Yield of Peach Palm in Hawaii.**
**C. R. Clement and R. M. Manshardt.**

The peach palm is being evaluated in Hawaii as a source of fresh hearts of palm. Nine open-pollinated progenies from the Benjamin Constant population of the Putumayo landrace are planted at three densities: 1.5 x 2 m (3333 plants/hectare); 1 x 2 m (5000 pl/ha, the commercial density in Costa Rica); 1 x 1.5 m (6666 pl/ha). Harvest started at 15 months after planting and four months later 25% of the plants had been harvested, with 25%, 30% and 21% at 3333, 5000, and 6666 pl/ha, respectively. Mean heart diameters were unaffected by density (mean±SD = 3.2 ± 0.4 cm). Heart lengths were similar (24 ± 5 cm, 23 ± 6 cm, 26±5 cm, respectively), as were heart weights (200 ± 41 g, 187 ± 44 g, 224 ± 42 g, respectively). This relative uniformity was unexpected, as density effected all of these yield components in earlier experiments in Latin America. Potential yields were different (667 ± 136 kg/ha, 835 ± 221 kg/ha, 1491 ± 275 kg/ha, respectively), and are comparable to yields reported from Costa Rica. Actual precocious yields, however, were not different (167 kg/ha, 278 kg/ha, 385 kg/ha, respectively).

**Genetic Variability for Precocious Palm Heart Yield of Pejibaye in Hawaii.**
**C. R. Clement and R. M. Manshardt.**

The peach palm is being evaluated in Hawaii as a source of fresh hearts of palm. Nine open-pollinated progenies from the Benjamin Constant population of the Putumayo landrace are planted at three sites in a randomized complete block design.

The best site started yielding at fifteen months after planting, the intermediate at sixteen months, the poorest at eighteen months. During the first four months of harvest at the best site, 25% of the plants were cut; during three months at the intermediate site, 15% were cut; during the first cut at the poor site, 1% were cut. Progeny harvest percentages ranged from 7 to 53% at the best site, with only three progenies above average (33, 47, 53%). These are considered to be precocious. These three progenies produced average size hearts (172 ± 36, 204 ± 57, 203 ± 44 g/plant, respectively; experimental mean±SD = 205 ± 53 g), but yielded above average at 5000 plants/ha (275, 480, 524 kg/ha, respectively; exp. mean = 272 kg; corrected for % cut). Potential yields of these progenies were near the mean (871 ± 198, 1018 ± 280, 983 ± 197 kg/ha, respectively; exp. mean = 986 ± 381 kg/ha), but their precocity provides early returns to the farmer.

**Response of Pejibaye to Herbicides and Black Polypropylene Mat During Establishment in Hawaii.**

**J. DeFrank and C. R. Clement.**

Peach palm is being evaluated for palm heart production in Hawaii. Yields and weed control were evaluated in response to: oryzalin (4.5 and 9.0 kg ai/ha), oxyfluorfen (0.6 and 1.2 kg ai/ha), paraquat (1.2 and 2.4 kg ai/ha) and woven black polypropylene mat. Four open-pollinated progenies from the Benjamin Constant population of the Putumayo landrace were used as replications. Paraquat was sprayed at 50 day intervals, while the preemergence herbicides were sprayed at ninety day intervals. Harvest started at eighteen months after planting out, seventeen months after treatment initiation. The polypropylene mat yielded the highest percent harvest (80%), followed by oxyfluorfen (50%), paraquat (20%), oryzalin (12.5%). There were replication (genotype) effects that suggest varying tolerance to paraquat and oryzalin. Estimated palm heart yields (3731 plants/ha), corrected for % harvest, were highest with polypropylene mat (490 kg/ha), followed by oxyfluorfen 1.2 ai (425 kg/ha) and 0.6 ai (330 kg/ha). Paraquat severely inhibited growth of the suckers that assure future harvests. The performance rating of these weed control treatments was: mat = oxyfluorfen > oryzalin > paraquat.

**Precocious Response of Pejibaye to Legume, Grass, and Black Polypropylene Groundcovers During Establishment in Hawaii.**

**J. DeFrank and C. R. Clement.**

Peach palm is being evaluated for palm heart production in Hawaii. Counts of parasitic nematodes, yields at 18 months and weed control were evaluated in response to: *Arachis pintoi*, *Cassia rotundifolia* cv. Wynn, *Desmodium ovalifolium*, *Chloris gayana*, and woven black polypropylene mat. Four open-pollinated progenies from the Benjamin Constant population of the Putumayo landrace were used as replications. Twenty-five percent of the plants were harvested, with means of 5, 20, 15, 15, and 70%, respectively. Individual heart weights did not vary significantly among treatments (mean = 169 g). Actual yields were significantly different, with means of 31, 125, 92, 99, and 440 kg/ha, respectively. All vegetative ground covers competed with pejibaye for nutrients, which explains the harvest percentages and yields. *D. ovalifolium* and *C. gayana* provided acceptable weed control. *A. pintoi* provided good ground cover, but no weed control.

# Tissue Culture Propagation of Atemoya and Starfruit

**L. Agus Sukamto**
**Department of Horticulture**
**University of Hawaii at Manoa**

# Atemoya (*Annona squamosa* L. X *A. cherimola* Mill.)

Epicotyls and hypocotyls of atemoya produced multiple shoots, after they were cultured on Murashige & Skoog (MS) medium with 1 uM 2,4-dichlorophenoxy acetic acid (2,4-D), 1 uM naphthalene acetic acid (NAA), 1 uM benzylaminopurine (BAP), 2 mg/l L-proline, and 1 mg/l L-glutamine and tranferred to 1/2 MS medium with 4.44 uM BAP. Shoot regeneration occurred directly from epicotyls and hypocotyls, even though limited callus was produced from excised epicotyls and hypocotyls of atemoya.

**Introduction**

Atemoya is a natural hybrid between sugar apple and cherimoya which originated in Florida (Jordan and Botti, 1992). This plant has some cold tolerance and high fruitfulness (Alexander et al., 1982), can be grown well in lowland tropical and subtropical areas (Campbell, 1976), and is produced commercially in Queensland and New South Wales, Australia (Bourke, 1976).

The juvenile period is about five years so grafting or budding methods with mature scion is preferable. The juvenile period of scions is greatly influenced by seedling rootstocks which can be highly variable (Jordan and Botti, 1992). Seedling production through tissue culture will overcome variability of atemoya rootstock. Atemoya rootstock is also compatible with scion of other annonas (Bourke, 1976). The objective of this experiment was to produce uniform rootstock and to develop atemoya propagation through tissue culture.

**Materials and Methods**

The seeds were sterilized with 70% alcohol and 5% clorox, washed with sterile water, and sowed on 1/2 MS medium. Hypocotyls and epicotyls of seedlings were cut about 1 cm length, grown on MS medium with 1 uM 2,4-D, 1 uM NAA, 1 uM BAP, 2 mg/l L-proline, and 1 mg/l L-glutamine, and transferred to 1/2 MS with 4.44 uM BAP.

**Results and Discussion**

The hypocotyls and epicotyls of atemoya released some phenolic compounds which appeared as browning on tissues as well as on medium, but this compound did not harm further development.

The tissues grew slowly, formed callus on the excised parts and multiple shoot buds on the first medium, and grew profusely after they were transferred on 1/2 MS medium with 4.44 uM BAP.

Multiple shoots were produced directly from hypocotyls or epicotyls but not from callus. This result was different with another and leaf culture of sugar apple which produced callus before forming multiple shoots on Nitsch & Nitsch or MS medium with combination of auxin and cytokinin (Nair et al., 1983; 1984), but similar result with hypocotyl culture of cherimoya on MS with 0.5 mg/l NAA and 2 mg/l BAP (Jordan, 1988).

The shoots could be separated and cut for further multiplication. These shoots did not produce roots, auxin treatment or cutting 2.5 cm length of the tissues may produce roots as similar result on hypocotyl-derived shoots of cherimoya (Jordan, 1988).

**Acknowldgement**

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# Starfruit (*Averrhoa carambola* L.)

Seedlings and cotyledons of starfruit produced multiple shoots on 1/2 Murashige & Skoog (MS) medium with 1 mg/l benzylaminopurine (BAP). The seedlings formed multiple shoots without previously producing callus, whereas the cotyledons produced callus before producing shoots. Cotyledon-derived shoots were more vigorous than seedling-derived shoots, and formed some fasciated stems.

**Introduction**

Starfruit is an evergreen tree which can bear fruit continuously throughout the year on tropical and subtropical areas (Litz and Griffis, 1989). Commercial production of starfruit increased in the island countries of the Caribbean, Central and South America, and Southeast Asia for local market or export to North America and Europe (Litz and Griffis, 1989).

The plant is cross-pollinated so the variability of plant is very high and the juvenile period is four to five years (Tidbury, 1976). Vegetative propagation is normally done by grafting or budding because air-layering or cutting is unreliable and unfeasible (Litz and Griffis, 1989).

Occasionally, seed propagated plants are used for ornamental purpose or when vegetatively propagated plants are lacking (Litz and Conover, 1980), even though the quality fruit of starfruit, seed propagated is usually inferior (Litz and Griffis, 1989).

Propagation of starfruit through tissue culture will provide abundantly uniform plants as well as rootstocks in relatively short time. Several researchers have done work on tissue culture of starfruit: Rao et al. (1981) using cotyledon as explant, but failed to regenerate plants from cotyledon callus; Litz and Conover (1980) and Litz and Griffis (1989) using leaf as explant, they succeeded in regenerating shoot but frequency of shoot differentiation was low and occurred in a short time. The objective of this experiment were to produce uniform rootstock and to develop starfruit propagation through tissue culture

**Materials and Methods**

Mature seeds were sterilized with 70% alcohol, 5% clorox, washed with sterile water, and sowed on 1/2 MS medium. Germinated seedlings and their cotyledons were transferred to 1/2 MS with 1 mg/l BAP.

**Results and Discussion**

Starfruit seeds took several months for germination. The seedlings grew rapidly on 1/2 MS medium. The growth of root growth was inhibited or ceased after transfer to medium with 1 mg/l BAP.

Multiple shoots were formed on the base of seedling stem directly without callus formation. Shoot regeneration occurred only on 1 mg/l BAP, whereas Litz and Conover (1980) observed that it only occurred on high concentration of cytokinin (2 - 10 mg/l 2iP) from callus of leaf culture. Seedling-derived shoots shed some leaves but not as many as reported by Litz and Griffis (1989).

The cotyledons formed callus on the excised tissues on MS medium with BAP. This proved that auxin is not necessary for callus formation of starfruit cotyledon. This result contradicted the observation of Litz and Conover (1980) who mentioned that the presence of 2,4-D was necessary for initiation and growth of callus.

Cotyledon callus produced multiple shoots which were more vigorous than those of seedling-derived shoots. This also proved that shoot regeneration of cotyledon callus occurred without including embryo axis which was contrary to statement of Rao et al. (1981). Cotyledon-derived shoot formed some fasciated stems. This fasciated stem is desirable for ornamental purpose.

**Acknowldgement**

The author wishes to thank Dr. Y. Sagawa for the use of his laboratory and for assisting with this paper.

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# Biological Control of Fruit Flies in Hawaii: Prospects and Problems

**Russell Messing**
**Department of Entomology, College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa, and**
**Mary F. Purcell**
**USDA-ARS Tropical Fruit and Vegetable Research Laboratory, Hilo**

**Introduction**

Four species of tephritid fruit flies infest many of the marketable fruits and vegetable produced in Hawaii, and are considered to be among the main obstacles to a more robust and diversified agricultural economy in the state. Biological control, in which a beneficial organism or "natural enemy" kills or controls a pest, is a critical but underappreciated component of fruit fly control throughout the islands. There is a great deal of potential to improve biological control by better understanding and management of populations of these beneficial species.

**What Types of Organisms Kill Fruit Flies?**

Beneficial organisms generally belong to one of the three P's: parasites; predators; or pathogens. All three are well represented in efforts of fruit fly biocontrol.

**Parasites**

Dozens of species of parasitic wasps have been imported into Hawaii over the past eighty years. These wasps were generally found in the same region of three of the four species of tephritid fruit flies (three came from southeast Asia and the fourth is a Mediterranean fruit fly that was originally from Africa). The wasps attack **only** flies, and are completely harmless to humans, other animals, and plants. Adult female wasps sting the fly eggs or larvae and deposit their own eggs inside. When these eggs hatch, the wasp larvae devour the flies from the inside out. There are two broad groupings of flies: specialists (family Braconidae), which attack only fruit flies; and generalists (Chalcidoids), which attack other types of flies as well as fruit flies.

**Predators**

When fruit fly larvae are fully grown they exit the fruit by jumping and burrowing into the soil in order to form pupae. During this period on the ground, they are very susceptible to being eaten by generalist predators, such as the big-headed ant. Some studies have shown that ants can kill up to 35% of the fruit flies pupating beneath guava trees. Beetles, earwigs, and even mice and birds can also kill their share of flies. In Europe, researchers have shown that large wasps, such as yellow jackets, swoop in and capture adult flies while they oviposit into fruits on a tree. These wasps actually use the flies' own pheromones (sex attractants) as cues to hone in on their prey.

**Pathogens**

Like most other animals and insects, fruit flies have their share of diseases. Some strians of bacteria are potent insect pathogens, and researchers are testing whether *Baccilus Thuringiensis* (which is widely used to kill caterpillars on fruits and vegetables) can also be used to kill fruit flies. Some species of beneficial nematodes, when applied to the soil, have been shown to kill a large percentage of fruit fly larvae.

**Is Biological Control Effective?**

It is not generally appreciated how effective biological control agents in Hawaii are at controlling fruit flies. However, studies have shown that parasites are, in fact, doing a tremendous job in reducing fly population throughout the state. For example, in 1949 (prior to the introduction of the egg parasit *B. arisanus*) mango, avocado, and guava frequently had over a houndred Oriental fruit flies per fruit! Also, banana, papaya, lychee, citrus, and passion fruit all used to be much more infested. Since its introduction, *B. arisanus* has been show to parasitize over 50% of each generation of more eggs. This raises the overall fly mortality rate to 95%!

**How Can Biological Control be Improved?**

Current natural enemy impact is insufficient to give complete control of any of our fruit fly pests in Hawaii, but there is obviously much room for improvement. Entomologists from the USDA-ARS and CTAHR are working jointly to devise augmentation strategies for mass-rearing and release of millions of parasites in the field at key periods in the fruit flies' life cycle. By increasing the ratio of parasites to flies, higher levels of parasitism may be achieved. Better understanding of the biology and behavior of the wasps may also enable us to manage and manipulate their populations in the field. CTAHR researchers are studying the learning capacity of wasps to see if they can be "trained" to be more effective incertain crops.

The importation of new species of parsites from Asia, Africa, and South America into Hawaii has great potential to increase the levels of biological control. Literally dozens of species have already been identified, and only await importation and testing. Additional species, new to science, undoubtedly exist as well.

**What are the Major Obstacles?**

Because in many cases fruit flies are quarantine pests, biological control alone will never be sufficient to give the level of control needed to export crops. Hence, some entomologists are looking at parasites as an adjunct to sterile fly releases or other methods of control. Exploration for new natural enemy species in many tropical countries is fraught with logistical difficulties, including stringent collection and shipping permit requirements, and the danger of disease, political instability, and other health hazards for the explorer.

Importation of new parasites must pass through a stringent quarantine process at the Hawaii Department of Agriculture (DOA), and then go through an extremely long and complicated series of bureaucratic hurdles before they can be released. The bureaucratic process has become so daunting that some researchers have given up trying. And some "environmentalists" now consider parasites more dangerous than pesticides, and are trying to regulate the process to death.

For production of many tropical fruits and vegetables in Hawaii to increase substantially (in order to help replace the declining sugar industry with a more diversified agriculture), the problem with tephritid fruit flies must be ameliorated. Biological control with natural enemies offers one of the most environmentally safe, proven, and cost effective techniques to combat these pests.

# Identification of Lychee Cultivars by Isozyme Fingerprinting

**Francis Zee, USDA-ARS National Clonal Germplasm Repository, Hilo**
**Malli K. Aradhya and Richard M. Manshardt**
**Department of Horticulture, College of Tropical Agriculture and Human Resources,**
**University of Hawaii at Manoa**

**Introduction**

Lychee (*Litchi chinensis* Sonn.) is native to subtropical China and northern Vietnam (Groff, 1921), and is an important commercial crop grown in China, Thailand, and Taiwan for major markets in Singapore, Hong Kong and Japan (Chapman, 1984). Other markets exist in Europe, North and South America and Australia. Lychee has the potential to become an export crop for Hawaii.

Standardization of cultivars is a prerequisite for commercial production of high quality fruits. Confusion regarding cultivar names still exists in current lychee collections. Discrepancies have arisen from:

(1) the fact that most Chinese cultivar names exist in two dialect forms, Cantonese and Mandarin ("putonghua") (Groff, 1921; Watson, 1984), e.g. the cultivar Hak ip is a romanization based on the Cantonese pronunciation, while Hei ye is based on the Mandarin pronunciation.

(2) the presence of variants and seedlings selected from popular cultivars. For example, the different forms of No mai t'sz include Lo kang No mai t'sz , Wong No mai t'sz (yellow No mai t'sz) (Anon., 1986), and the early, medium and late types of No mai t'sz in Guangdong, were all reported to have different seed size, production and fruit qualities (Chapman, 1984). Variants of Kwai mi include Lo kang Kwai mi and Ap tau luk Kwai mi of Guangdong (mallard head green) (Anon., 1978; Groff, 1921), and the Kwai mi pink and Kwai mi red from Australia.

(3) the lax use of popular cultivar names and use of local names by nurseries, farmers, hobbyists and fruit traders. Some examples are: (a) In Hawaii, the variety Tai so has been wrongly called Kwai mi since the time it was brought in by Chinese immigrants. (b) O-hai , Baidum (Thailand), Woo yip , Hak yip and Hei yue (China) are all regional names for Hak ip. (c) Wai chi resembles Hak ip in general fruit features and was often sold as Hak ip in the Chinese markets. In Chan ts'un (Chan's village) of Shun tak, a lychee cultivar known as Kam chai t'sz (golden hair pin) is also called Hak ip, while it superficially resembles, but the fruit is sweeter and has a smaller seed (Groff, 1921).

The current classification criteria for lychee are based on both fruit and leaf descriptions. However, interpretation of these is highly subjective and dependent on the experience of the person and the availability of fruits. Isozyme electrophoresis is a biochemical method which allows for more objective classification and requires only a small amount of healthy leaf tissue from each tree.

Isozyme electrophoresis detects and resolves the multiple molecular forms or polymorphisms of an enzyme on the basis of their differential migration rates in a standardized starch gel when subjected to an electrical field. Individual plants differ in their isozyme profiles or fingerprints , and many samples can be run on a single gel. Each gel can be sliced horizontally into thin slabs to be stained for different enzymes.

The objectives of this study are:

(1) to fingerprint and classify lychee cultivars using isozyme markers.
(2) to assess the level and organization of genetic variability in the lychee cultivar collection in Hawaii.

**Materials and Methods**

Forty-nine lychee accessions maintained at the USDA-ARS, National Clonal Germplasm Repository (NCGR) in Hilo were subjected to isozyme fingerprinting using starch gel electrophoresis. Twelve enzymes were assayed and ten were used to establish the identities of the accessions. The isozyme data were analyzed based on the similarities and differences in polymorphisms between accessions.

**Results and Discussion**

Forty of the 49 lychee accessions exhibited unique fingerprints, thus providing information necessary for the identification of cultivars. This study provided some unique information on the composition of the current collection. It identified accessions that have different names but showed identical fingerprints, while others had identical names but different isozyme patterns (Table 1).

The Kwai mi accession in Hawaii was previously reported to be identical to Mauritius in Hawaii (from South Africa) (Yee, 1972) and Tai so in Australia (Menzel and Simpson, 1991). Our study confirmed that Hawaii Kwai mi was identical to Hawaii Mauritius and also Kim jee from Thailand, but different from Kwai mi from Guang xi, China. Based on the morphological descriptions in Chinese literature and the results from this study, we deduced that Kwai mi in Hawaii is probably the cultivar Tai so . Tai so will be introduced from China to provide the direct isozyme comparison in the future. The isozyme pattern of Mauritius in Hawaii was found to be different from that of Mauritius at the USDA-ARS, Miami Repository in Florida, in agreement with a report (Storey, 1972) on morphological differences between these accessions.

One accession of No mai tsz from Maimi Repository was isozymically identical to Shan chi in the same collection. The former was presumably a rootstock that regenerated following the devastation of hurricane Andrew in August, 1992, since Shan chi or mountain lychee is commonly used as a rootstock for No mai t sz in China (Groff, 1921). Eight variants of No mai t'sz were identified in the collection, all having distinct isozyme patterns, suggesting that the name of the parent clone was commonly applied to seedlings of No mai t'sz .

The Hak ip accession in Hawaii was collected by Groff from China in 1941 and was recorded as Punyu Tuwah Shui Tung Haak ip (Storey et al., 1953). Its isozyme pattern was found to be different from Hak ip from Guang xi, China, but identical to Kwang tung from Taiwan, which, according to Menzel and Simpson (1991), is the same as the Souey tung in Australia (Table 1).

If you are not totally confused by now with these Chinese names, and if you are interested in reading more about our isozyme work, I would urge you to get a copy of our paper, which will be available in late summer of 1995:

Aradhya, K.M., Zee, F.T. and Manshardt, R.M. 1995. Allozyme variation and differentiation in lychee (*Litchi chinensis* Sonn.). Scientia Horticulturae (in press).

This partial listing of discrepancies between the cultivar names and the true identities of lychee accessions at the repository demonstrates an inherent problem in plant exploration and preservation - one cannot just blindly trust the labels that come with the plants - what the label says is not necessarily what you are getting.

Isozyme electrophoresis is a powerful tool that can be used to check the validity of lychee cultivar names in a matter of days instead of months or years as required by morphological descriptors. One of the critical requirements for isozyme fingerprinting is the availability of authentic cultivars as standards. It is, therefore, a priority for the Hilo repository to collect and establish a comprehensive collection of lychee cultivars and germplasm from gene banks and agricultural institutes in their counties of origin for purposes of germplasm preservation and identification.

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Table 1. A partial list of lychee accessions with different names but identical fingerprints, and ones with identical names but different isozyme fingerprints.

| Cultivar | NCGR ID # | Origin | Isozyme locus* 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kwai mi | 6 | Hawaii | | | | | | | | | | | | |
| Mauritius | 7 | Hawaii | AA | AA | BD | AC | CD | BC | BD | BD | BB | BB | AB | AB |
| Kim jee | 14 | Thailand | | | | | | | | | | | | |
| Nomaitsz | 39 | Florida | | | | | | | | | | | | |
| Shan chi | 38 | Florida | AA | AA | CD | AA | BC | CC | CD | BB | BB | BB | AA | AB |
| Hak ip | 8 | Hawaii | | | | | | | | | | | | |
| Kwang tung | 24 | Taiwan | AA | AA | DD | BC | BD | CC | CD | BD | BB | BB | BB | BB |
| No mai tsz | 3 | Hawaii | AB | AA | DD | CC | AB | CC | CD | BB | BB | BB | BB | AB |
| | 16 | Florida | AB | AA | CD | CD | AB | CC | AC | BB | BB | BB | AB | BB |
| | 17 | Florida | AA | AA | DD | CD | BB | CC | CC | BB | BB | AB | AB | BB |
| | 19 | Taiwan | AA | AA | CD | CD | AA | CC | AC | BC | BB | BB | AB | AA |
| | 27 | Taiwan | AA | AA | CD | CD | AA | CC | AC | BC | BB | BB | AB | AB |
| | 30 | China | AA | AA | DD | DD | BB | CC | CC | CC | BB | AB | CC | AB |
| | 36 | Florida | AB | AA | DD | CC | BC | CC | CC | BD | BB | BB | AB | AB |
| | 49 | Hawaii | AA | AA | CD | CD | BC | CC | AC | BB | BB | BB | AB | BB |
| Hak ip | 8 | Hawaii | AA | AA | DD | BC | BD | CC | CD | BD | BB | BB | BB | BB |
| | 28 | China | AB | AA | CD | DD | BC | CC | AD | AB | BB | BB | AB | AA |
| Kwai mi | 6 | Hawaii | AA | AA | BD | AC | CD | BC | BD | BD | BB | BB | AB | BB |
| | 29 | China | AB | AA | CD | CD | AB | CC | CD | BC | BB | BB | AA | BB |
| Mauritius | 7 | Hawaii | AA | AA | BD | AC | CD | BC | BD | BD | BB | BB | AB | BB |
| | 34 | Florida | AA | AA | BD | AD | BC | AC | AB | BD | BB | AB | AA | BB |

* *1 = Idh-1, 2 = Idh-2, 3 = Mdh-2, 4 = Per-1, 5 = Pgi-2, 6 = Pgm-1, 7 = Pgm-2, 8 = Skdh, 9 = Tpi-1, 10 = Tpi-2, 11 = Ugpp-1, 12 = Ugpp-2*

# Field Trip Notes

**Craig Elevitch**
**Ka'aina Pono**

**An Enduring Agriculture - Land of Abundance**

Most indigenous cultures, such as the Hawaiians', cultivated the earth, fulfilling their needs for food, materials and medicine for generations, balancing their needs with their natural resource base. The modern concept of "permaculture" combines "permanent" and "agriculture" to describe agricultural systems which provide for people indefinitely. Permaculture draws from Hawaiian indigenous agriculture, either indigenous practices, and the life sciences to create enduring, productive systems that mimic the diversity and stability of nature. Many farmers have begun to question the ability of chemically-based agriculture to sustain itself, and are rediscovering the knowledge and methods upon which permanent agricultural systems have always been based. Ka'aina Pono has as its vision to be a model of permaculture in Hawaii.

**Ka'aina Pono Project Goals**

The permaculture project at Ka'aina Pono will establish a model and a training center of self-reliant, sustainable resource for small land holdings in the tropics. This will demonstrate:

- agroforestry systems with a regenerative effect on local ecology;
- commercial viability of diversified agriculture;
- on-site generation and use of organic fertilizers;
- minimized off-site inputs of water and fuel;
- optimal use of space and time for high productivity in a small area; and
- soil and water conservation practices;

Long-term benefits of the permaculture project at Ka'aina Pono will include:

- establishment of a food forest ecosystem including commercial production, enhanced natural beauty, added stability and fertility of the land, improved watershed (better moisture retention), resource self-sufficiency, and wildlife habitat;
- subhumid agroforestry, including multi-purpose, nitrogen fixing, native, and food-producing trees;
- permanent ground covers and contour hedgerows for erosion control;
- shelter belts (windbreaks) of useful species; and
- integration of nutrient flows from aquaculture and home waste with orchard.

**Phased Implementation**

The full implementation of this design will take shape in phases, over a period of about two years:

**Phase I July-September 1994:** Establishment of soil and water conservation measures including contour hedgerows and ground covers to stabilize soil and boost fertility. Conversion of certain areas of the farm to agroforestry.

**Phase II October 1994-September 1995:** Expansion of plantings. Forming initial connections between the home, the aquaculture system, and the agroforestry component.

**Phase III October 1995-onward:** Developing systems to full-scale productivity, value-adding on-site and direct marketing. Extension work and model training center for sustainable agriculture in the subhumid tropics.

**Design Elements:**

**Permanent Ground Cover**

The existing ground cover is a mixture of fast growing weeds common to areas regularly sprayed with Round-up: herbaceous shrubs such as spanish needles, legumes such as desmodium and mimosa (sleeping grass), and grasses such as California grass and wire grass. In this case we have a very tame mix of weeds, and we are proceeding by selectively pulling out the noxious weeds such as California grass, rampand desmodium, and tall woody weeds. The grasses are removed and mulched or composted and soft herbs cut to regrow and provide organic matter.

The nitrogen fixing vines *Arachis pintoi* (perennial peanut) and *Desmodium heterophyllum* (Hetero) will complement the existing weeds, with other plants such as cherry tomatoes, poha, sweet potato, nasturtium, etc., spotted in for diversity. The perennial peanut grows well in shady conditions, and therefore makes a good ground cover under tree canopies; hetero is an excellent edge plant for paths. Over time, the ground cover will evolve, consisting of the most useful and desirable weeds together with a low growing cover of nitrogen fixers.

The addition of mineral amendments (rock phosphate and lime at 500 lbs/acre each) are used to enhance the health of the vegetative flora. also, regular applications of agrispon metabolic soil stimulator, humic acid, and algae micronutrients are low cost beneficial additions.

**Contour hedgerows**

The prime functions of contour hedgerows are erosion control and organic matter production. hedgerows are pruned back about 3 times per year, with the trimmings used for mulch around trees and shrubs. Certain hedgerow species can also be used for animal fodder.

Results from a recent LISA for Hawaii project (report available) on organic matter production indicated that the technique can replace a large proportion of chemical fertilizer, at the same or less cost. The cost of establishing, maintaining, and pruning the hedgerows was comparable to the cost of fertilizer replaced, with many other added benefits such as erosion control, pole wood, fuel, and fodder. Soil nutrient levels in mulched areas around trees improved by a factor of 3 or more.

Double hedgerows designed as per SCS specifications were installed at Ka'aina Pono begining July 1994. The primary species are: *Calliandra calothyrsus*, *Acacia angustissima*, *Leucaena diversifolia*, *Flemingia macrophylla*, *Cajanus cajan* (pigeon pea), *Sesbania sesban*, *Paraserianthes falcataria*, and *Cassia siamea*.

**Shelter Belts**

Damaging winds are always a risk to plantings in Hawaii, making windbreaks an essential element of an agricultural system. Shelterbelts protect from wind and provide privacy, fruits, beauty and wildlife habitat. Our windbreaks include fruit trees including coconut, jackfruit, and spodilla. A living fence of natal plum keeps out intruding animals such as dogs, horses, and cows.

**Long-term Stacked Cropping System**

Plant assemblies of groundlayer (e.g., herbs, leguminous ground covers), mid-layer (papayas, bananas), and upper-layer (e.g., fruit and timber species) form natural ecosystems. Such systems have the stability and productivity of natural forests. Microclimate enhancement using a nurse crop of pioneering species such as nitrogen fixing trees is essential in the development of the system.

**Tree-based Agriculture for the Subhumid Tropics**

Tree crops form the basis of a stable agriculture in semiarid lands, primarily due to their extensive root systems, accumulation of organic matter, and resilience to extended periods of drought. A forest garden forms the core of agricultural acitvites on the project.

**Multipurpose Trees in Agricultural Systems**

Multipurpose trees give added stability to a natural farming system. Trees with more than a single yield also give economic benefits to the farmer, albeit often these are difficult to measure economically. Some functions of trees that are of interest in arid lands are shade, fruits, medicine, insecticidal properties, nitrogen fixation, timber, fodder, erosion control, and wind control.

**Training Areas of Ethnobotanical Species**

Arranged by place of origin, useful plant species are grouped to form living classrooms for ethnobotanical instruction. As more species are acquired, they will be introduced into the ethnobotanical islands: America (Amazonia, Central America, Mexico), Asia (Indonesia, India, China), Hawaii (native Hawaiian and Polynesian introduced), and Persian.

**Integration of Animals**

Animals play an essential role in the biological function of soils and plants: they move nutrients, seeds, and energy in a form of ecological information transfer. Domestic animals such as ducks (pond-land ally) and chickens (garden-ally) will be integrated. Desirable wild and feral animals such as birds, bees, bats are also encouraged actively trhough provision of forage and habitat.

**Aquaculture**

The pond systems which are proposed bring aquatic life into the system, such as fish, ducks, frogs, etc. They demonstrate traditional and new water polycultures, including the use of diverse pond edge and marsh area plantings to make optimum use of the water resource. Additionally, they function as water storage and nutrient reservoirs for use in plant fertigation.

**Commercial activities**

The project exemplifies low-imput on-site production and value-added processing. Operations will be certified by organic standards.

**Representative Multipurpose Plant List**

| Common Name | Species Name | A | B | C | D | E | F | G | H | I |
|---|---|---|---|---|---|---|---|---|---|---|
| Allspice | *Pimenta dioica* | 3 | 1 | 2 | | 1 | | | | |
| Avocado | *Persea americana* | 2 | 1 | 2 | | 2 | 2 | | | |
| Breadfruit | *Artocarpus communis* | 2 | 2 | 2 | | 2 | 2 | | 1 | 1 |
| Caimito | *Chrysophyllum cainito* | 2 | 1 | 2 | | 2 | | 1 | 1 | |
| Canistel | *Pouteria campechiana* | 2 | | 1 | | 2 | | | | |
| Cashew | *Anacardium occidentale* | 2 | 2 | 3 | | 2 | 2 | 1 | | 2 |
| Cinnamon | *Cinnamomum zeylanicum* | 2 | 1 | 1 | | | | | | |
| Clove | *Syzygium aromaticum* | 2 | 1 | 2 | | | | | | |
| Coconut | *Cocos nucifera* | 3 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | |
| Feijoa | *Feijoa sellowiana* | 2 | 2 | 2 | | 1 | 1 | | | |
| Gruminchama | *Eugenia braziliensis* | 2 | 1 | 2 | | 1 | | | | |
| Jaboticaba | *Myrciaria cauliflora* | 1 | | | | 2 | | | | |
| Jackfruit | *Artocarpus heterophyllum* | 3 | 2 | 2 | | 2 | 2 | 2 | | 3 |
| Kukui | *Aleurites moluccana* | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 |
| Langsat | *Lansium domesticum* | 2 | | 1 | 2 | 3 | | | | |
| Longan | *Dimnocarpus longan* | 2 | 1 | 2 | | 2 | | 2 | | 3 |
| Loquat | *Eriobotrya japonica* | 1 | | 1 | | 2 | 2 | | | |
| Lychee | *Litchi chinensis* | 2 | | 1 | | 2 | 1 | 2 | 2 | |
| Mango | *Mangifera Indica* | 2 | 2 | 2 | | 3 | 2 | 3 | | 2 |
| Mountain apple | *Eugenia malacsensis* | 2 | 2 | 2 | | 2 | 1 | | 1 | |
| Mulberry | *Morus nigra* | 2 | 3 | 2 | 3 | 2 | 3 | 1 | 2 | 2 |
| Natal Plum | *Carissa grandiflora* | 2 | 2 | 3 | | 1 | | | | |
| Neem | *Azadirachta indica* | 2 | 2 | 3 | | | 2 | 2 | 2 | 2 |
| Santol | *Sandoricum koetjape* | 1 | | 1 | | 1 | | | 1 | |
| Sapodilla | *Minilkara zapota* | 3 | | 2 | 1 | 3 | 2 | | 2 | |
| Seagrape | *Coccoloba uvifera* | 2 | 2 | 2 | | 1 | | | 1 | |
| Strawberry guava | *Psidium litorale* | 2 | 3 | 3 | 2 | 2 | 2 | 1 | 2 | 2 |
| Sugarcane | *Saccarum officianale* | 2 | 1 | 1 | 1 | 2 | 3 | | 2 | |
| Surinam cherry | *Eugenia uniflora* | 2 | 1 | 1 | | 1 | 1 | | | |
| White sapote | *Casimiroa edulis* | 2 | 2 | 2 | | 2 | 1 | | 1 | |

A= Wind tolerance: 1=good as minor windbreak component; 2= good windbreak; 3=excellent wind tolerance.
B= Pioneer: 1= grows in full sun, depleted soils; 2= same as 1 but fast growing; 3= same as 2 and vigorous and spreading.
C= Drought tolerance: 1= 50+ inches annually, 1-2 months dry; 2= 30+ inches annually, 2-3 months dry; 3= 20+ inches annually, 3-5 months dry.
D= Wet: 1= tolerates poor drainage; 2= tolerates poor drainage and flooding; 3= tolerates long periods submersed.
E= Food: 1= out-of-hand or marginal quality; 2= good quality; 3= excellent quality
F= Fodder: 1= has edible parts of marginal quality; 2= good quality fodder; 3= outstanding fodder quantity and quality.
G= Fuel: 1=has burnable parts; 2=good fuel source; 3=excellent quality fuel products.
H= Erosion: 1=fair stabilization of soils; 2= good soil stabilization; 3= excellent erosion control.
I= Wood: 1= marginal wood products; 2= good wood for timber or crafts; 3= excellent timber.
Blank spaces= information not available.

## Biological Management of Understory Vegetation in Macadamia Orchards

**Kent Fleming and Kathleen Delate**
**Department of Agricultural and Resource Economics**
**College of Tropical Agriculture and Human Resources,**
**University of Hawaii at Manoa**

The objectives of the USDA Sustainable Agriculture Research and Education project shown at the Kona Experiment Station are the following:

To develop and to demonstrate large-sale and small-scale orchard-pastoral management systems which incorporate sound grazing and flock management strategies that complement orchard operations.
To identify and to quantify the biological, soil (i.e. overland flow and sediment loading) and social factors associated with the inclusion of grazing animals in orchard environments.
To determine the economic feasibility of sustainable macadamia nut, avocado, and lychee orchard production systems which rely on biological methods, and to compare the economics of the sustainable system with the conventional (more chemically dependent commercial production system).

This site is located at about 1,500 ft. elevation in arid, rocky mountainous terrain on the leeward side of the Island of Hawaii. The climate is characterized by tropical temperatures (60 to 80 degrees F) with rainy summers and dry winters. The terrain is primarily *a'a* lava partially covered with a thin layer of easily erodable tropical soil. The soil is nitrogen-leached and low in organic matter. The addition of nutrients via compost and/or animal manures is critical for sustainable crop production. The main focus of the project for 1993-94 was the quantification of soil erosion in the pastoral-orchard systems versus the conventionally managed orchard (herbicide/mowing). Monitoring the erosion hazard of a particular farm site is essential in assuring the sustainability of the farm enterprise. Through a monitoring program, one can detect wind and water patterns which create problems for field stability. Accelerated erosion is induced by activities such as the raising of crops and livestock. The inclusion of conservation practices, such as cover crops and reducing tillage operations, will help serve to mitigate the erosion hazard by providing a protective barrier to erosive factors. Both sheet erosion (even removal across sloping lands) and rill erosion (concentrated water flow in rills) constitute the main forms of erosion on the farm site.

Because rainfall and runoff can lead to soil detachment and erosion, we designed a catchment system to quantify soil loss from the sites. In order to ascertain the effect of sheep grazing on the erosion hazard of the farm site, we began measuring the following parameters: monthly quantity of rainfall; and volume of overland flow (rainfall erosivity).

Results demonstrate a reduction of overland flow of rain in the sheep-grazed (agro-pastoral) system compared with the conventional system (Table 1), leading to a lower erosion hazard in this system. Comparison of nutrient runoff from the two sites may also demonstrate the value of sheep-grazed orchards in retaining nitrogen and phosphorus in soil vs. leaching into groundwater resources.

Organic agro-pastoral management was more complicated than initially anticipated. High tensile electric fencing was the most cost-effective means of containing the flock and excluding predators. However, since the organic farmers could not use herbicides to control weeds at the base of the fence, hand weeding was required. This process was excessively time consuming; thus, we designed a fencing system (hog wire with one electric strand along the top to exclude predators) which would eliminate the weeding. It could function effectively but would involve a higher capital cost. Another alternative would be to eliminate the top strand and place a donkey inside with the sheep to protect the sheep from predators, as has been suggested by various shepherds.

Other problems that occurred with sheep grazing under avocado trees included their de-barking the tree roots and trunk. De-barking is harmful to the health of the tree and reduces avocado yield. Uncontrolled de-barking will kill the tree. However, it appears that sheep do not initially de-bark; rather, it is a learned behavior. Unfortunately once they begin to de-bark, it is difficult to reverse this behavior. However, it does appear that de-barkers can be culled (or transferred to a macadamia nut orchard) and new sheep can be introduced to the avocado orchard to avoid the debarking problem.

It is believed that the sheep must be rotated periodically to avoid over-grazing and feeding on alternate sources (bark and husks). Currently, sheep are rotated every 7-8 weeks; the ideal rotational program should be based on the condition of the grass and sheep consumption rates. A critical area is necessary for a sheep grazing project; an acre of orchard with sufficient ground cover between tree rows should suffice for a flock of five sheep. The lychee and macadamia nut orchard at the Kona Experiment Station appears to supply an adequate amount of pasture grazing area (one acre) during the summer and fall seasons of adequate rains. During the dry winter months, however, an alternate pasture area and/or feed must be provided.

The primary economic benefit of the agro-pastoral system is significantly lower weed control and pruning costs. The sheep enterprise itself is not thought of as a "profit center." Rather the enterprise operating costs are covered by the sale of lambs in the fall. The small-scale sheep enterprises are managed by orchardists with little or no livestock experience and the enterprise is not envisioned to be an intensive, profit-maximizing effort, but at MacFarms, with 610 sheep, the gross savings from utilizing sheep to supplement orchard weed control and pruning activities amounted to $121 per acre per year. There were no net costs associated with using the sheep in that their costs were more than covered by lamb sales. (The price for finished lambs has been rising steadily and the sheep enterprise may therefore eventually generate a significant direct profit, but conceptually the sheep will continue to be viewed as "mowing/pruning machines")

The greatest contribution of this project will be the development of an economically feasible agro-pastoral system, using sheep for weed management, pruning and nutritional enhancement in tropical orchard systems. Orchard production is the major diversified agricultural commodity group in hawaii. and with the decline of the sugar and pineapple plantations, orchard production is becoming a relatively more important component of the state's agricultural sector. Information on sustainable alternatives to herbicides for orchard weed control, lower input alternatives to high labor costs, and sustainable alternatives to highly leachable, synthetic fertilizers because of the potential for new restrictions on groundwater pollutants under the Coastal Zone Management Act will help farmers consider alternatives to conventional farming.

**Table 1. Catchment system output and rainfall.**

| Time Period | Accumulated Rainfall | Overland Flow- No Sheep | Overland Flow- Sheep Included |
|---|---|---|---|
| 10/19/93 to 11/9/93 | 1.50 in. | 25.75 in. (in catchment barrel) | 22.00 in. |
| 11/9/93 to 11/18/93 | 1.40 | 6.75 | 2. 50 |
| 11/18/93 to 3/4/93 | 3.77 | 13.75 | 1.25 |
| 3/4/94 to 5/24/94 | 6.38 | 17.00 | 6.50 |
| 5/24/94 to 6/30/94 | 4.55 | 16.00 | 3.25 |
| 6/30/94 to 7/15/94 | 2.31 | 10.50 | 3.25 |
| 7/15/94 to 7/29/9494 | 0.97 | 6.88 | 0.75 |
| 7/29/94 to 8/12/94 | 2.05 | 8.75 | 2.50 |
| 8/12/94 to 8/26 | 3.20 | 26.25 | 9.00 |
| 8/26/94 to 9/1/94 | 3.52 | 53.00 | 44.50 |

# Appendix:
# Australian System of Funding Research and Promotion

*The following was presented by H. C. Bittenbender, Department of Horticulture, University of Hawaii at Manoa. The information comes from "Horticultural R & D Funding - An Overview" (April 1994), a summary of the operations of the Horticultural Research & Development Corporation, New South Wales, Australia.*

Over the past 12 months the Horticultural Research and Development Corporation (HRDC) has seen continued growth in its funding activities.

The research and development program undertaken by the HRDC has grown from $9.5 million in 1991/92 to $17 million in 1993/94 - a pleasing result given the overall economic environment.

Strong growth of funding is expected to continue in the areas of genetic improvement, pest and disease management and value adding and new product development.

The increased financial commitment of participating industries reflects acceptance of the Corporation as the research arm of the horticultural industries. Each industry, through a research and development committee is able to establish its own program based on identified priorities and this close involvement with the Corporation in determining the funding of projects gives each industry a sense of ownership and responsibility for its own research needs.

**Levies**

New R&D levies were introduced for cherries and custard apples during 1993/94 and the rates of levy for the apple, pear, and macadamia industries were increased. Negotiations have continued with the tablegrape, stonefruit and vegetable industries over the introduction of levies.

In addition to this, a strong level of voluntary contributions was achieved in what was a difficult financial year for many horticultural industries. The continuing strong level of voluntary contribution indicates a firm long term commitment by industries to support R&D activities as an investment in the future.

However, despite the promising outlook there still remains a number of industries who are not yet taking full advantage of the funding arrangements provided by the Commonwealth government through the HRDC.

**Strategy**

In 1992/93 the Corporation added quality management as a strategy area aimed at supporting the development of Quality Management Systems (QMS). This area is now supporting 12 projects with a total budget in excess of $350,000.

In supporting industry participation in QMS, the Corporations's objective is to obtain information on the costs and benefits to horticultural industries of an investment in a quality management system.

Research into pest and disease management continues to make up a significant part of overall Corporation funding. It should be realized however, that this research is directed toward reducing industry reliance on pesticides through the use of integrated pest management systems in order to meet consumer and market requirements.

In the area of genetic improvement, the HRDC initiated a review of potato breeding and variety information in order to assess the overall benefits to industry of work in this area. As a result of this review a National Management Committee was put in place to ensure the breeding and evaluation program continues to meet industry needs.

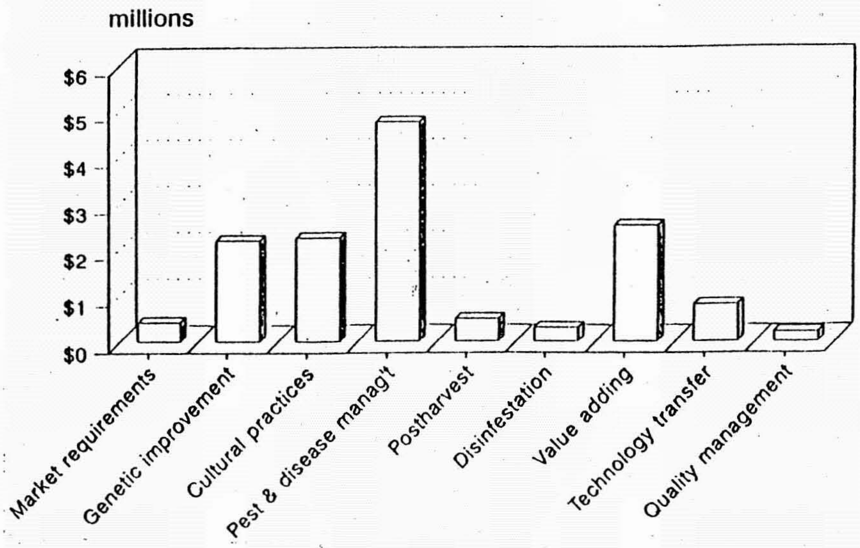
The Corporation continues to strongly support technology transfer through the use of Industry Development Officers (IDO's). While extension activities are required to be inherent in all projects supported by HRDC, the use of IDO's provides a strong industry focus and communication structure through which to disseminate research results.

In overall terms the R&D effort is directed at maintaining and improving present viability, while at the same time investing in the future growth and international competitiveness of Australian horticulture.

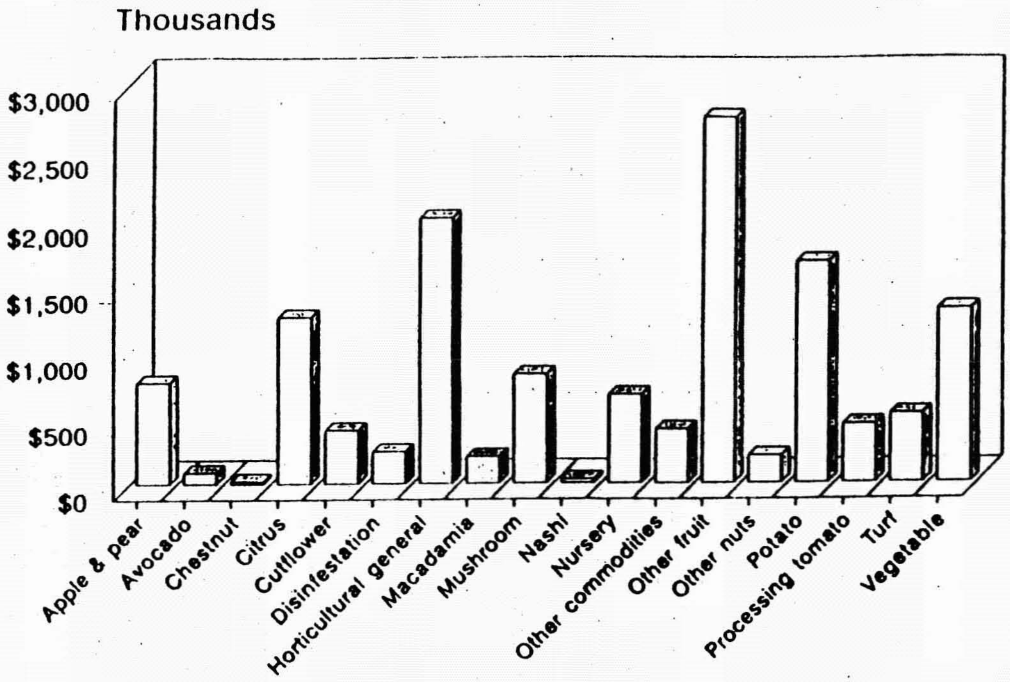
**Industry Liaison/Planning**

In developing its research program the Corporation has consulted closely with a wide range of industry bodies including: eligible industry bodies in the citrus, apple and pear, nursery, macadamia, potato, avocado, chestnut and nashi industries (statutory levies); industry organization such as the Queensland Fruit and

## 1993/94 R&D Program - by Corporate Strategy




## R&D Program 1993/94 - by Industry




Vegetable Growers and the mushroom and processing tomato industries (voluntary contribution arrangement); and other R&D Corporations (opportunites for coordination and cooperation).

The HRDC recognizes the importance of this consultation in promoting a better understanding of the Corporation's objectives and activities and assisting individual industries to develop research and development priorities.

The HRDC reports to levy paying industries annually as part of its statutory requirements, and liaises continually with these and other non-levy paying industries at other times.

The Corporation has used planning workshops for the cherry, vegetable and stonefruit industries to develop programs and determine industry research and development priorities. The use of formal workshops has assisted in developing R&D priorities tuned to the needs of individual industries.

Industry liaison also continues through individual industry research and development committees which review applications submitted to the HRDC for funding. These committees make recommendations to the Corporation on funding priorities based on industry needs.

**R&D Coordination**

The HRDC has continued to support a series of research coordination meetings aimed at minimizing the degree of duplication of research effort. In 1993/94 meetings were held to address research in the following areas: cadmium, citrus breeding and evaluation, citrus quality management, Western Flower Thrips, Integrated Pest Management (IPM) for potatoes, disinfestation and market access.

**How the HRDC operates**

As the body responsible for the coordination and funding of horticultural research and development, the Horticultural Research and Development Corporation is the research arm of the Australian horticultural industries.

A self-supporting Australian Government statutory organization, the HRDC was established in 1988 with the aim of improving the efficiency and competitiveness of Australian horticulture and ensuring accountability for expenditure on research and development.

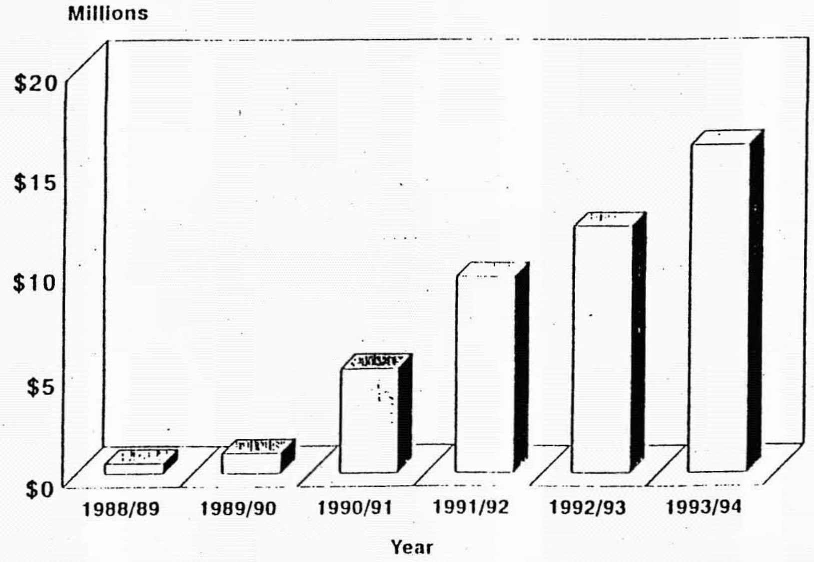
Funding of research and development by the HRDC is on the basis of equal cost sharing by industry and the Commonwealth Government on a dollar for dollar basis up to a set maximum level based on 0.5% the industry's gross level of production. A percentage of project cost has been extablished as an administration charge, half of which comes from the industry and the other half from the Commonwealth. This administration charge has been reduced from 20% in 1988/89 to 7% in 1993/94.

Funds are collected in one of three ways: a statutory levy (introduced at industry request following widespread consultation) a voluntary levy or through project related voluntary contribution (used to address a specific industry R&D need).

HRDC's coordinating role covers all horticultural products including fruits, vegetables, nuts, turf, nursery products, and cut flowers and foliage and includes production, postharvest and processing research and development. The only specific restriction to the type of research and development projects eligible for consideration are that they must relate to horticultural products and be of direct relevance to industry priorities.

In 1994/95 the HRDC estimates it will support a budgeted program of close to $20 million.

HRDC Total R&D Program - 1988/89 to 1993/94



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