

FOREWORD

Citrus originated in Southeast Asia, where it is today one of the most important fruit crops. However, yields per unit area in Asia are low compared to most Western countries. This Bulletin discusses the problems of growing citrus in Malaysia, and the programs which are under way to improve the quality and quantity of the citrus harvest.

Malaysia not only has a tropical climate, but is humid all year round. Whereas neighboring countries tend to have a monsoon climate with pronounced wet and dry seasons, Malaysia has an even distribution of rainfall throughout the year. This promotes the spread of pests and diseases. Greening disease is a particularly serious problem. The Bulletin describes current control programs, which emphasize the production of disease free planting materials and integrated pest management. The use of tolerant rootstock is giving good results in the control of phytophthora rot and trysteza, two other serious diseases of citrus.

The author has considerable experience of the problems faced by small-scale citrus farmers in Malaysia, and how these problems can be solved in efficient, cost-effective ways. He has worked with Malaysian farmers for many years to help them develop and improve their citrus production. This Bulletin is based on a paper first presented by the author at an international seminar on "*Citrus Production In Asia* ", held in Cheju Island, Korea in October 1996. It was co-sponsored by the Cheju Citrus Research Institute, of the Rural Development Administration of Korea, which graciously provided the venue.

OVERCOMING THE PROBLEMS OF CITRUS PRODUCTION IN MALAYSIA

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ABSTRACT

The problems of citrus production in Malaysia are mainly due to the prevalence of pests and diseases, and poor management of soils and fertilizers. The selection of suitable clones or varieties with both high-quality fruit and disease resistance is important for improving citrus production.

Soil acidity causes certain microelement deficiencies, and it is necessary to apply limestone to raise the soil pH. Organic manures are applied to improve soil structure in areas of high rainfall where there is rapid leaching of soil nutrients.

*In high rainfall areas, a soil-borne fungal disease caused by *Phytophthora* is prevalent, but it can be effectively controlled by the use of tolerant rootstock and the application of metalaxyl and fosetyl-Al.*

*Existing trees in the field are almost all infected with tristeza virus, but it is no longer a problem because most varieties used in Peninsular Malaysia for fresh fruit consumption, such as mandarin and sweet orange, are tolerant to this disease. Moreover, the disease can be controlled by the use of tolerant rootstock. However, greening disease still remains a major threat to the citrus industry. The propagation of disease-free planting materials through shoot tip grafting, as well as the control of the vector *Diaphorina citri*, are the main measures to prevent the spread of greening disease.*

INTRODUCTION

Citrus has been chosen as one of the 16 fruit types for commercial production under the Malaysian National Agricultural Policy. Areas suitable for citrus cultivation include both highlands and lowlands (Chan *et al.* 1981).

In Peninsular Malaysia, citrus production has declined from 3,670 ha in 1970 to 2,487 ha in 1985. The decline in production has mainly been because of disease — virus and virus-like diseases, and *Phytophthora*. Since 1985, the area under citrus cultivation has begun to increase, stimulated by various government incentives and new methods of controlling pests and diseases.

Of Malaysia's total fruit growing area, only 2% was used for citrus cultivation in 1985, and 1.7% in 1989. Although the area planted in citrus has increased, it has not expanded as fast as the area planted in other fruits (Table 1).

With the rising demand for citrus in Malaysia, therefore, the volume of imported citrus has always been high, and is increasing every year. There is a need to increase citrus production, to reduce the cost of imports and meet the demand of a growing population. Studies conducted by the Federal Agricultural Marketing Authority (FAMA) showed that citrus consumption in Malaysia increased from 48,826 mt in 1989 to 55,667 mt in 1991. With an estimated *per capita* consumption of 10 kg per year, the projected citrus

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Table 1. Total fruit areas and citrus in Peninsular Malaysia

	Citrus (ha)	Total fruit production area (ha)	% citrus/fruit area
1970	3,673	69,963	5.2
1975	2,582	74,826	3.5
1980	2,741	116,858	2.3
1985	2,487	122,011	2.0
1989	2,807	165,650	1.7
1993	4,773	236,093	2.0

Source: *Buku Maklumat Perangkaan Pertanian Malaysia*

consumption in the year 2000, with a population of 25 million, is estimated to be 250,000 mt per year. Assuming a yield of 20 mt/ha/year, this would imply at least 12,500 ha of citrus. However at the rate that the citrus acreage is expanding in Malaysia, the projected area under cultivation may only be 5,266 ha in the year 2000.

SUITABLE CLONES AND VARIETIES IN CITRUS PRODUCTION

The most common types of citrus cultivated in the lowlands are mandarin and pomelo. There are also a number of processing varieties, such as the sour lime and musk lime. By careful selection of the various clones and varieties, grapefruit, sweet orange, mandarin and pomelo can be further improved for cultivation in the lowlands (Table 2). Since pomelo in Peninsular Malaysia are not susceptible to the greening disease, their commercial production can be expanded. An area of 4,773 ha was planted in pomelo in 1993, and this type of citrus seems to be increasing the fastest (Table 3). One of the best pomelo varieties is a variant of the Sha-tian, which is often grown in the south of Peninsular Malaysia. The established varieties are grown near limestone hills in the district of Kinta, about 200 km north of Kuala Lumpur. At present, new clones of pomelo are being selected to replace some of the established pomelo varieties. The final choice of suitable varieties will have to be based on selection experiments in the field.

The best clones of Limau Langkat (Malayan mandarin: *C. suihsensis* Hort. ex Tan.) come from the eastern state of Trengganu in Peninsular Malaysia. For some

time, this was the only variety cultivated in Malaysia, and was widely grown throughout the country. Recently, the introduced Yala mandarin "Chokun" from southern Thailand has gradually been replacing the Limau Langkat because of its superior fruit quality. However, the Yala mandarin is very susceptible to both bacterial canker and greening disease. It is also a carrier of a severe strain of tristeza virus. Moreover, blemished skin and fruit cracking are common problems in Yala mandarin.

The main indigenous varieties of citrus consist of the acid types, which are easier to grow than sweet orange or mandarin. These include sour lime (*C. aurantifolia* [Christm. & Panzer] Swingle) and musk lime (*C. madurensis* Lour.). Both of these are being exploited commercially for processing and industrial uses. In contrast to sweet orange and loose-peel types of citrus, a strong orange or red color in the rind is not desirable in acid citrus used for processing.

Although land is readily available in the lowlands for agriculture, it is difficult to grow citrus fruits with a rind color comparable to that of imported ones. The degreening process turns the fruit yellow, rather than a deep-orange color. The planting of suitable citrus varieties with good cosmetic appeal is thus limited to the highlands, at altitudes of 800-1500 m above sea level. Sweet orange, particularly the navel varieties, and also certain mandarin varieties, are grown in the Cameron Highlands (Table 2). These varieties can be further developed in other highland areas to meet the needs of the local Chinese population, since at present, supplies for the festive season are traditionally imported from China. Land suitable for agriculture is

Table 2. Citrus varieties and clones grown in Malaysia

	Lowlands <300 m above sealevel	Highlands 800-1500 m above sealevel
Mandarin (loose peel types)	Langkat Chokun Cembol Bintangor	Langkat Liukan Ponkan Tankan
Sweet orange	Cula Haji Dollah Kempis Wangkang	Liucheng Valencia Washington navel Thomson navel
Grapefruit	Marsh Yellow	Marsh Yellow Duncan Red Blush
Pomelo	Tambun White Tambun Pink Sha-tian	
Processing varieties	Limau Nipis Limau Kasturi Limau Pagar Limau Mata Kerbau Limau Belalang Tahiti lime Meyer Villafranca Lisbon	Bearss lime Meyer Villafranca Lisbon

Source: Santiago 1962

Table 3. Production area (ha) of various kinds of citrus in Malaysia

	1987	1993
Mandarin (Langkat)	345	487
Sweet orange	667	1,117
Pomelo	631	1,724
Others (limes etc.)	601	1,445
Total citrus	2,244	4,773

becoming scarce in the highlands. The difficulty of planting citrus on steep slopes also increases the cost of production. However, this has been off-set by higher yields, the result of high-density planting and better management in the highlands (Table 4).

PESTS AND DISEASES IN CITRUS PRODUCTION

The fact that a citrus orchard is not being properly managed is often indicated by the presence of sooty mold (*Capnodium citri*

Table 4. Production costs and farmers' income in citrus farming in Malaysia
unit: US\$/ha

Items	Pomelo (lowland)	Mandarin (lowland)	Mandarin (highland)	Navel orange (highland)
1) Production costs				
Orchard establishment	1,120	240	1,200	1,200
Fertilizers	848	920	1,320	1,320
Labor (self-supplied)	2,160	2,228	2,738	2,273
Animal labor	-	-	-	-
Machine labor	-	-	-	-
Chemical and Herbicide	278	1,040	1,842	2,000
Energy	480	480	600	600
Materials	320	200	600	720
Direct Costs-Total	5,206	5,108	8,300	8,113
Building expenditure (Depreciation)	-	-	-	-
Farming tools (Depreciation)	200	320	480	480
Tax and fees	400	400	800	800
Land interest	240	240	400	400
Capital interest	-	-	-	-
Indirect cost-total	840	960	1,680	1,680
Total cost	6,046	6,068	9,980	9,793
2) Income and net profits				
Product quantity (kg/ha)	17,000	15,960	40,000	30,000
Product value (gross)	20,400	19,152	48,000	42,000
Net profit (income-cost)	14,354	13,084	38,020.5	32,207
3) Other data				
Product cost/100kg	36	38	25	33
Labor — hours/ha	1,440	1,485	1,825	1,515

1US\$ = 2.5 Malaysian Ringgit

Berk. & Desm.) on the trees. This shows the need for regular spraying with pesticides. Pests and diseases are extremely serious in citrus production in Malaysia, and are the main reason why citrus is such a difficult fruit crop to manage. Malaysia's humid environment, together with the high temperatures, predispose the trees to many severe pests and diseases.

The most important problems in citrus production have always centered on pests and diseases. When citrus production was encouraged in the early 1960s, most plantings were wiped out by a severe soil-borne disease caused by *Phytophthora* (Wong and Varghese 1966). Even where *Phytophthora* collar and root rot disease was not present, the trees were found to be unhealthy and unproductive.

They were in fact showing the typical symptoms of greening disease, although this was not diagnosed until 1987 (Aubert 1989, Ko and Shamsudin 1987, Lim *et al.* 1989).

Greening is the worst threat to citrus production, not only in Malaysia but also in other parts of Asia, and in Africa (Garnier and Bove 1993). The disease is caused by a "bacterium-like" organism (Garnier *et al.* 1987). It is transmitted by a psyllid, *Diaphorina citri* Kuw. (Martinez and Wallace 1967), although it has also been widely spread by the propagation of planting materials from infected trees. Although antibiotics have been found to be effective against greening disease (Buitendag and Bronkhorst 1984), it is impractical to use this method of control. There are no resistant or tolerant varieties of

mandarin or sweet orange in Malaysia. However, certain varieties in Thailand have been reported to be tolerant of greening disease (Koizumi *et al.* 1993). Because of the mode of infection, rootstock is useless as a means of control. Normally, greening-infected scions grafted onto tolerant rootstock will eventually die off, leaving behind the rootstock to grow into a tree.

Leaf symptoms of greening disease are very similar to those of zinc deficiency. The symptoms of chlorosis, dieback and stunted growth can be confused with other citrus diseases and disorders (Table 5). However, the symptoms do differ in that they always first appear on only one part of the tree, while the other parts remain healthy. The greening organism does not appear to be translocated to other parts of the tree. Detection by plant indexing appears to be difficult, as the greening organisms are

normally located in the young shoots (Ko 1988). Some efficient and rapid methods have been developed to detect the disease in the laboratory (Bove *et al.* 1993, Korsten *et al.* 1993).

Disease-free planting materials have been produced to overcome the problem of greening disease infection, using the following methods:

- Nucellar seedling selection;
- Thermotherapy and shoot tip grafting;
- Introduction of disease-free citrus varieties.

Tristeza virus infection is controlled together with greening disease. In the control of vector-borne diseases such as tristeza and greening, the planting of disease-free materials is impractical unless the young trees are isolated from the inoculum source and vectors. Re-infection in the field appears to kill young disease-free trees even faster than trees that are already carrying the pathogen. Protecting

Table 5. Comparative symptomatology of three citrus diseases

Symptoms	Greening	Tristeza	Phytophthora
Stunted growth	+	+	-
Leaf chlorosis			
sectorial on certain shoots	+	-	-
overall leaf chlorosis	-	+	+
sectorial interveinal chlorosis	+	-	-
veinal chlorosis	-	+	+
mottling	+	+	-
Vein corking	+	+	-
Leaf curling and distortion	+	+	-
Small upright leaves	+	+	-
Dieback of branches	+	+	+
Fruit - drop	+	?	-
lopsided	+	-	-
aborted seeds	+	-	-
small size	+	+	-
green and orange color on the peel surface			
when mature ('red-nose' symptom)	+	-	-
mummified shape	+	+	-
Trunk and branches			
gummosis (collar region)	-	-	+
necrotic lesions (collar region)	-	-	+
stem pitting on susceptible varieties	-	+	-
Root rot	-	+	+

+ present, - absent

Source: Ko 1991

the trees from psyllids and aphids by the use of insecticides is not always possible. Alternate hosts for the psyllids (Lim *et al.* 1990), together with any old, infected trees, need to be removed before any disease-free trees are planted. Extensive programs to educate Malaysian farmers about the seriousness of greening disease have been carried out by extension advisors. Seminars and workshops have been held, and agricultural extension workers have been trained to recognize the symptoms of greening disease in the field.

Tristeza is not considered as serious as greening disease, as far as mandarin and sweet orange production is concerned. The use of tristeza-tolerant rootstocks has extended the life span of many tristeza-infected trees (Table 6). However, some tristeza-infected mandarin and sweet orange trees are carriers, and remain a source of infection to many susceptible varieties such as sour lime and musk lime.

Phytophthora collar rot and gummosis disease used to be a severe disease of many varieties of sweet orange, pomelo, grapefruit, lemon and limes propagated by marcotting (air-layering). The loose-peel Limau Langkat (mandarin) is also susceptible to the fungus under certain conditions. The use of tolerant or resistant rootstock is a practical long-term

control measure (Table 6), together with the application of effective systemic chemicals such as metalaxyl and fosetyl-A1. With the use of these methods, the disease is now no longer a problem in Malaysia's citrus production.

Bacterial canker (*Xanthomonas campestris* pv. *citri*) has become a serious disease in citrus nurseries, affecting the growth of Troyer citrange and citrumelo rootstock in the lowlands. The appearance of bacterial canker on trifoliolate rootstocks is a recent problem, which occurred with the introduction of the Yala mandarin from Thailand. Although this introduced mandarin variety is severely affected by bacterial canker, the local Limau Langkat (mandarin) appears to be very tolerant. Bacterial canker is present in lime, citron and lemon (Tai 1969), but has never been a serious problem in several varieties of mandarin, sweet orange or pomelo.

Lowland citrus trees are under heavy attack from a number of serious pests (Table 7). The trend in pest control is towards integrated pest management (IPM), with a reduction in the use of chemical pesticides. The use of petroleum oils has given much better control of aphids, thrips, scale insects and mites. These pests normally cause blemishes on the fruit, thereby reducing their cosmetic appeal.

Table 6. Disease-tolerant rootstock for citrus

Rootstock	<i>Phytophthora</i>	Tristeza
Rough lemon	- -	+ +
<i>Citrus volkameriana</i>	-	+
Liman Kasturi (lime)	+	- -
Cleopatra mandarin	+	+ +
Timkat mandarin	+ +	+ +
Sunki mandarin	-	+ +
Limau Langkat (mandarin)	- -	+ +
Rangpur lime	+	+ +
Sour orange	+ +	- -
Sweet orange	- -	+
<i>Citrus taiwanica</i>	+	+
Citrumelo	+ +	+ +
Troyer citrange	+	+ +
<i>Poncirus trifoliata</i>	+ +	+ +

- Moderately susceptible, + Moderately tolerant
 - - Fully susceptible, + + Tolerant/resistant

Table 7. Pests of citrus

Major pests	
Leaf miner	<i>Phyllocnistis citrella</i>
Mites	<i>Panonychus citri</i>
	<i>Tetranychus cinnabarinus</i>
	<i>Hemitarsonemus latus</i>
Thrips	<i>Scirtothrips citri</i>
Fruitfly	<i>Bactrocera (Dacus) dorsalis</i>
Aphids	<i>Aphis gossipii</i>
	<i>Toxoptera aurantii</i>
	<i>Toxoptera citricida</i>
Psyllids	<i>Diaphorina citri</i>
	<i>Diaphorina citri</i>
Minor pests	
Rind borer	<i>Prays citri</i>
	<i>Prays endocarpa</i>
Mealybug	<i>Planococcus citri</i>
Scale insects	<i>Coccus</i> spp.
	<i>Lecanium</i> spp.
	<i>Saissetia</i> spp.
	<i>Aonidiella</i> spp.
	<i>Chrysomphalus</i> spp.
	<i>Lepidosaphes</i> spp.
	<i>Unaspis</i> spp.
Stink bugs	<i>Rhynchocoris humeralis</i>
	<i>Rhynchocoris serratus</i>
Beetles	<i>Hypomoces squamosa</i>
Caterpillars	<i>Papilio polytes</i>
	<i>Papilio demoleus</i>
White fly	<i>Dialeurodes citri</i>
Black fly	<i>Aleurocanthus woglumi</i>

Source: Yunus and Balasubramaniam 1981

EFFICIENT SOIL AND FERTILIZER MANAGEMENT IN CITRUS PRODUCTION

Water-logged conditions in heavy clay soils is not conducive to citrus growth. Roots are stunted, and this eventually leads to the death of the tree. The wet soil conditions are also favorable for the spread of soil-borne fungal diseases such as *Phytophthora* collar and root rot. Therefore, a deep well-drained soil is usually selected for citrus production. It is more difficult to get rid of excess water from a soil than to apply water to it. Sandy soils, though infertile, are more suitable than heavy clay soils, provided there is good irrigation, and provided soil fertility is improved with liberal dressings of fertilizer and organic matter.

Soil acidity adversely affects the growth

of citrus. Trees growing in acid soils suffer from many problems of micronutrient deficiency. The most common disorder is zinc deficiency, which causes interveinal chlorosis of the young leaves. Symptoms of this disorder can easily be confused with those of greening disease. Therefore, limestone should be applied regularly to increase the soil pH. For this reason, pomelo normally grow well in areas near to limestone hills. If chemical fertilizers alone are applied, the soil will become too acidic for citrus growth.

Small-scale farmers in Malaysia receive a fertilizer subsidy for rice of 80 kg/ha mixed fertilizers and 40 kg/ha of urea. Farmers using urea from their rice fertilizer subsidy for citrus production increased the pH of the soil, thereby inducing zinc deficiency in the trees. Thus, when urea is applied, an equivalent

amount of lime should be added (Ignatieff and Page 1958). If farmers use only inorganic fertilizer, without any corresponding use of lime, the soil pH in their citrus plots never rises above 5.

In areas of high rainfall where leaching is common, organic fertilizers are essential, because they improve the soil texture as well as preventing leaching through their slow release of nutrients. Commercial slow-release chemical fertilizers are widely used, especially on sandy soils.

The following practices have been implemented to improve the nutritional status of citrus trees.

- Organic fertilizers and manures are used liberally. Many growers in the Cameron Highlands normally apply one bag of chicken manure (30-40 kg) under the canopy of each mature tree.
- Inorganic compound fertilizers containing the essential microelements are applied. Foliar sprays of microelements are normally applied to the trees at least four times a year.
- Since inorganic fertilizers tend to raise soil acidity, it is now common practice to apply lime together with the fertilizer.
- Localized spot placement of fertilizer is better than broadcasting, since it reduces surface run-off and leaching.
- Legumes are planted as a cover crop to reduce the requirement for nitrogen fertilizer. Legumes also prevent soil erosion on hill slopes, and help to control weeds.

CONCLUSION

Although many of the major problems of pests and diseases in citrus production have been overcome, there is still room for further improvement.

At present, there are no private nurseries that are producing disease-free citrus planting materials. There should be a nursery supervised by a government agency which is responsible for the production of scion-wood for growers. Indiscriminate use of marcotting to obtain planting material should be forbidden, to avoid spreading virus and virus-like diseases.

Growing citrus without the use of rootstock is outdated. A large plot of mother

trees for the production of rootstock seeds should be set up, so that seeds can be readily available for growers. At present, rootstock seeds are very expensive to import, and are not readily available.

Growing high-quality fruits for fresh consumption is at present restricted to smallholdings of about 2-3 ha. Growers are able to manage their orchards properly without hiring extra workers, and they can pay close attention to crop protection and plant nutrition.

If citrus are grown in very large orchards, it is difficult to produce high-quality fruit. Workers need to be hired, and since the trees do not belong to them, applications of pesticides and fertilizer are sometimes not carried out according to schedule, especially on steep terrain. There are problems in harvesting and tree pruning, unless machinery is used. Thus, only citrus varieties suitable for processing are grown on a large scale. These processing varieties are not as demanding in their requirements, in terms of crop protection and fertilizer applications.

However, varieties producing high-quality fruit for fresh consumption could be cultivated on a large scale if machinery is used and there is efficient management of labor. This would be an ideal way of expanding Malaysia's citrus production in order to reduce imports.

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DISCUSSION

One Korean participant was worried whether imports of mandarins and Ponkan oranges into Korea might carry the threat of greening disease. Mr. Ko pointed out that although greening disease is very important in Southeast Asia, it is not found in either Korea or Japan. Greening is not spread by imported fruits, as in the case of bacterial canker but is spread by a psyllid, *Diaphorina citri*, which thrives in warm moist conditions. If the temperature is too low for the psyllid, as in Korea and Japan, there is no problem of greening disease.