

POTENTIAL FOR EXPORTING FRUIT FROM PAPUA NEW GUINEA TO OVERSEAS MARKETS DURING THEIR OFF-SEASONS

C. Camarotto¹ and R. Michael Bourke¹

ABSTRACT

This study is an initial identification of fruit crops that could be exported from Papua New Guinea to nearby overseas markets during their off-seasons. The period of plentiful supply of 57 fruit and five nut species in Papua New Guinea is compared with that in two other Southern Hemisphere countries (Australia and Indonesia) and two nearby Northern Hemisphere countries (the Philippines and Thailand). Four basic patterns occur for the crops examined. Firstly, there are clear consistent differences between the main production periods in the Northern and Southern Hemispheres for some species, such as durian, rambutan and mandarin. For other species, such as avocado and watermelon, the production periods overlap in the two hemispheres. A few crops, such as banana and coconut, are non-seasonal in all locations. The fourth pattern is displayed by other species including guava, pawpaw and lime, for which production is non-seasonal in certain environments and seasonal in others. The best prospects for exporting fresh fruit from Papua New Guinea are for durian, langsat, mangosteen, pulasan and rambutan to certain Asian markets during the Northern Hemisphere non-production period. There is potential for other fruit exports to both Northern Hemisphere Asian markets and Southern Hemisphere markets in Australia, but this is limited by other factors including quarantine restrictions, the highly perishable nature of some fruit, limited demand and the poor quality cultivars grown in Papua New Guinea. Fruit in this category includes avocado, grapefruit, lime, mandarin, mango, pomelo, raspberry and strawberry.

Key words: Fruit, nuts, production season, export potential, Papua New Guinea, Australia, Indonesia, Philippines, Thailand.

INTRODUCTION

In recent years low world prices have led to a decline in the value of traditional export crops from Papua New Guinea (PNG). To counter this, alternative export crops need to be identified to supplement and even replace these. Globally, horticultural products have been growing in importance as agricultural exports from developing countries. Fruit constitutes 70 per cent of the total horticultural exports from developing countries and its relative importance has increased between 1975 and 1985 (Islam 1990:9). A number of horticultural crops have potential as exports, particularly if they can be supplied when the commodity is not in season in the overseas market (Fleming and Hardaker 1992). Fruit and

nuts have not been exported from PNG in the past.

There are four potential markets for PNG fruit and nut producers. These are:

1. **Fresh fruit sold within PNG.** There is a large unsatisfied demand for sweet fruit within PNG, particularly in the highlands and in certain lowland towns. Prospects for further domestic sales are very good for mandarin, mango, guava, pineapple, orange and rambutan.
2. **Processed indigenous nuts sold within PNG and overseas.** The potential for selling processed indigenous nuts on domestic and overseas markets is good. Galip nut (*Canarium indicum*) is the most promising and this species is being developed commercially in the Solomon Islands (Evans 1991),

¹Department of Human Geography, Research School of Pacific and Asian Studies, Australian National University, Canberra ACT 0200, Australia.

Vanuatu (Walter and Sam 1993) and Hawaii. Other indigenous nut species which have commercial potential are okari (*Terminalia kaernbachii*), aila (*Inocarpus fagifer*), pao (*Barringtonia procera*) and karuka (*Pandanus julianettii*).

3. Highland fruit species exported to Asia.

Potential exports for specialist producers include banana passionfruit (*Passiflora mollissima*), cape gooseberry (*Physalis peruviana*), cherimoya (*Annona cherimolia*), highland yellow passionfruit (sweet granadilla) (*Passiflora ligularis*), naranjilla (*Solanum quitoense*) and tree tomato (tamarillo) (*Cyphomandra betacea*).

4. Fruit exported to nearby countries during their off-season.

This paper is concerned with the last named potential market. Based on experience elsewhere, it was anticipated that the production period in PNG would generally be similar to that in other Southern Hemisphere countries and different from that in Northern Hemisphere countries (Stephenson 1991). Hence, PNG producers may be able to export fruit to major urban markets in Asia, such as Singapore and Hong Kong, during the non-producing period in the Northern Hemisphere. At the same time it needs to be recognised that producers in other Southern Hemisphere countries may be potential competitors for these markets. It is also possible that market niches for PNG produce exist in nearby Southern Hemisphere countries during their off-seasons. The Southern Hemisphere market considered here is Australia, but potential also exists for export to New Zealand.

In this preliminary study, the production patterns of 62 fruit and nut crops in PNG are compared with those in two nearby Southern Hemisphere countries (Australia and Indonesia)² and two nearby Northern Hemisphere countries (the Philippines and Thailand). The aim of this paper is to undertake an initial identification of potential crops that could be supplied during the off-

season in overseas markets. While the focus is on production periods, the actual export potential depends on many other factors including production costs, available germplasm, market prices, market demand, transport availability, marketing strategy, presentation and packaging (Cull 1984, Watson 1990). After identifying the crops with the greatest potential for off-season production, some consideration is given to these factors, but detailed analysis is required before export markets could be developed.

METHODS AND DATA SOURCES

The criterion for including a crop in this comparison was that reliable information was available on the crop's production period (seasonality) in PNG. In the initial selection of crops, agronomic suitability was not considered. In fact a number of the fruit crops examined do not produce well in PNG, such as apple, custard apple, plum and pomegranate. Reviews of fruit and nut production in PNG by Aburu (1982), Henty (1982), Tarepe and Bourke (1982) and Woodhouse (1991) indicate the suitability of different crops in different environments. A number of crops, which are important in Asian markets, are not considered because of lack of information on their production period in PNG, for example, lychee and longan.

After assembling the PNG data (Bourke *et al.* in press), information was sought from Australia (three states), Indonesia, the Philippines and Thailand. It was necessary to compile information from a number of sources for each place. We focus on the period when supply is plentiful, not the total production period. For example, some mandarin fruit may be produced in all months in PNG, but about 80 per cent of production occurs in the period May to August, and this is taken as the period of plentiful supply. This distinction is important for the study as we are interested in the period when fruit is in poor supply, but not necessarily completely absent, in the overseas market. However, the basis for defining this period is not always consistent between sources. In practice the production period may vary somewhat from year to year and between locations in the same state or country. For example, differences in the period occur between south and central Thailand and south and north Queensland. The production periods

² Most of Indonesia is located in the Southern Hemisphere, although some islands are just north of the equator. The data used here is from locations south of the equator

Table 1. Period of plentiful supply of 62 fruit and nut crops in Papua New Guinea (Highlands, Lowlands), Australia (Queensland, Northern Territory, New South Wales), Indonesia, the Philippines and Thailand**

Common name	Scientific name	PNG Hlands	PNG Llands	Australia QLD/NT	Australia NSW	Indonesia	Philippines	Thailand
Abiu	<i>Pouteria calmita</i>		1-12	1-12				
Apple	<i>Malus</i> sp.	3-4		12-4	1-4			6-7
Avocado	<i>Persea americana</i>	1-4	1-4	4-12	4-8	5-6; 12-2	2-7	5-7
Banana	<i>Musa</i> cvs	1-12	1-12	1-12	1-12		1-12	1-12
Brazil cherry	<i>Eugenia uniflora</i>		Irregular	3-5	3-5	5-6		
Breadfruit	<i>Artocarpus altilis</i>		Irregular	2-5		1-12	6-10	1-12
Bullock's heart	<i>Annona reticulata</i>		1-12	2-4			2-9	
Cape gooseberry	<i>Physalis peruviana</i>	1-12		1-12	1-4			
Cashew	<i>Anacardium occidentale</i>		10-1	8-1		6-9	3-5	2-4
Cherimoya	<i>Annona cherimolia</i>	6-9	7-10	3-5	4-5			6-9
Cherry guava	<i>Psidium cattleianum</i>		10-1	3-4	4-7			
Coconut	<i>Cocos nucifera</i>		1-12	1-12		1-12	1-12	1-12
Custard apple	<i>Annona atemoya</i>			2-7	5-9			
Custard apple	<i>Annona squamosa</i>		12-5			8-9	9-12*	6-9
Durian	<i>Durio zibethinus</i>		11-4	12-4		10-2	3-6*	3-6
Five corner (carambola)	<i>Averrhoa carambola</i>		1-12	1-12	3-5	1-12	4-6*	6-12*
Gallo	<i>Canarium indicum</i>		5-7					
Golden apple	<i>Spondias cytherea</i>		1-2	2-3		1-4		
Governor's plum	<i>Racourtia indica</i>		1-12	1-12	1-12	9-11		
Granadilla	<i>Passiflora quadrangularis</i>		1-12	1-12				
Grapefruit	<i>Citrus paradisi</i>	3-8		5-9	6-11			
Guava	<i>Psidium guajava</i>	2-5	1-12	1-12	3-5	2-3	7-9	1-12
Jackfruit	<i>Artocarpus heterophyllus</i>		1-12	1-12		1-12	3-8	1-5
Kumquat	<i>Fortunella japonica</i>		12-2	4-6	6-7			
Langsat	<i>Lansium domesticum</i>		1-2	3-5		11-2	8-11*	7-10
Lemon	<i>Citrus limon</i>	5-10		1-12	7-10			
Lime	<i>Citrus aurantifolia</i>		1-12	1-12*	2-8	4-7		5-9
Loquat	<i>Eriobotrya japonica</i>	3-7		7-9	6-8			
Macadamia	<i>Macadamia integrifolia/ M. tetraphylla</i>	12-4		2-6	2-7			.
Malay apple	<i>Syzygium malaccense</i>		12-1	2-4		8-9		11-3
Mandarin	<i>Citrus reticulata</i>	5-8		4-8	5-9	5-8	9-1	9-2
Mango	<i>Mangifera indica</i>		10-1	10-3	2-3	9-10	4-7	3-6
Mangosteen	<i>Garcinia mangostana</i>		11-3	11-3		11-3	5-10	5-9
Mulberry	<i>Morus nigra</i>	9-12		11-3	12-2			8-9
Orange	<i>Citrus sinensis</i>	4-8		5-8	10-2, 6-8		10-12	9-11
Passionfruit, banana	<i>Passiflora mollissima</i>	Irregular		9-2				
Passionfruit, hybrids	<i>Passiflora</i> spp.			1-12	1-12			
Passionfruit, highland yellow	<i>Passiflora ligularis</i>	Irregular		1-12				8-12
Passionfruit, lowland yellow	<i>Passiflora edulis f. flavicarpa</i>		1-12	2-6		1-12	1-12	1-12*
Passionfruit, purple	<i>Passiflora edulis f. edulis</i>	1-4		12-2	1-4	11-1		6-8
Pawpaw	<i>Carica papaya</i>	8-10	1-12	1-12	10-12	1-12	1-12	1-12
Pili nut	<i>Canarium ovatum</i>						6-8	
Pineapple	<i>Ananas comosus</i>	9-3	10-3	1-12	12-2	1-12	4-6	1-12
Plum	<i>Prunus</i> sp.	Irregular		10-3	11-3			4-5
Pomegranate	<i>Punica granatum</i>		12-5	1-6	2-3	11-12	9-12	10-12
Pomelo	<i>Citrus maxima</i>		1-12	2-9		4-7	9-1	8-11*
Pulasan	<i>Nephelium mutabile</i>		11-3	12-8		10-12		5-9
Rambutan	<i>Nephelium lappaceum</i>		2-5	12-8		11-2	5-8*	5-9
Raspberry, black	<i>Rubus lasiocarpus</i>	1-12		10-5	12			
Raspberry, red	<i>Rubus</i> sp.			10-5	11-6			
Rockmelon (cantaloupe)	<i>Cucumis melo</i>		8-11	1-12	12-5	1-12	12-3	1-3
Rollinia	<i>Rollinia deliciosa</i>		1-12	2-8				
Santal	<i>Santalum koetjape</i>		12-3	1-3		11-12	6-10	5-7
Sapodilla	<i>Manilkara zapota</i>			6-12	3-5		10-6	9-12
Soursop	<i>Annona muricata</i>	1-12	1-12	1-12		1-12	8-11	5-8*
Star apple (calmito)	<i>Chrysophyllum cainito</i>		12-1	7-11	7-11	5-7	12-4	
Strawberry	<i>Fragaria</i> sp.	6-9		6-10	9-5	7-9	12-4	12-3
Tamarind	<i>Tamarindus indica</i>		4-6	8-11		6-9	2-5*	12-2
Tree cucumber	<i>Averrhoa bilimbi</i>		1-12	1-12		1-12	1-12*	1-12
Tree tomato (tamarillo)	<i>Cyphomandra betacea</i>	3-4		2-12	3-8			
Watermelon	<i>Citrullus lanatus</i>		11-3	9-4	12-2		11-3	10-3
Watery rose apple	<i>Syzygium aqueum</i>		Irregular	2-4	.	Irregular		1-3*

* Conflicting data from different sources

**Periods are months of supply with the numbers 1, 2 etc. referring to January, February etc.

were often longer or commenced earlier for locations nearer the equator. Detailed information on this variation for PNG is given in Bourke *et al.* (in press).

When discrepancies occurred in the data obtained, further clarification was sought, either from the literature or through communication with relevant experts. Where conflicting information from different sources could not be resolved, this is indicated in the main data set (Table 1). In Australia, information was obtained on the production period in New South Wales, Queensland and the Northern Territory. The Australian market is highly integrated and produce can be readily transported to distant markets within Australia. Hence we have generally considered the Australian material together.

Data Sources

The following sources are used:

The data for PNG is derived from Bourke *et al.* (in press), in which the following unpublished sources were used:

Surveys of five highland food markets by R. M. Bourke, E. J. D'Souza, K. Nema and T. N. Tarepe for the period June 1979 to September 1982.

Experimental observations recorded by S. Woodhouse at the Lowlands Agricultural Experiment Station, Keravat for the period January 1989 to March 1993.

PNG Food Marketing Corporation purchase figures for the period April 1976 to August 1981 for six purchasing centres in the highlands and lowlands.

Prices for 14 food crops and betel nut for the period January 1971 to December 1992 recorded in five urban centres. Together with other price data, these are used by the National Statistics Office to calculate the Consumer Price Index.

Observations by a network of observers for mango (5 years) and karuka nut pandanus (10 years) at a number of locations.

Collation of available literature and inter views with villagers by one of us (RMB).

K. Chapman was the primary source for Queensland and he also provided information for all other locations except PNG. Other information for Queensland and the Northern Territory was obtained from R. Broadley and V. Kulkarni and papers by Alexander (no date), Hanlon, Chacko and Baker (1989), O'Hare and Vock (1990), Wait and Jamieson (1983) and Watson (1990). Information for New South Wales came from publications by the NSW Department of Agriculture (no date a and b), Beattie (1982) and from M. R. Loebel.

The Indonesian information was largely extracted from IBPGR (1980) and from J. Kartasubrata. This was supplemented by material in Verheij and Coronel (1991). The core data for the Philippines were obtained through correspondence with C. Escano and E. Lopez, supplemented by information in Coronel (1991). The primary source for Thailand was the publication Fruits in Thailand by the Department of Agricultural Extension (1987). Other sources included P. Boonkinkajorn and S. Vasuvat. Supplementary information was extracted from Verheij and Coronel (1991).

RESULTS AND DISCUSSION

Information on the period of plentiful supply of 57 fruit and five nut crops is summarised in Table 1. Periods for the PNG lowlands (sea level to 1200 m altitude) and the highlands (1200 to 2800 m) are presented separately. Similarly, the Australian data are given for northern Australia (Northern Territory and Queensland) and southern Australia (New South Wales). Information on 15 of the most promising potential exports from PNG is presented in Figures 1, 2 and 3.

Production periods in the five countries

Distinct differences in the production period occur between locations in the Northern and Southern Hemispheres. For a number of fruit crops, the contrast between locations in the two hemispheres is particularly marked. The fruiting pattern of mangosteen illustrates this contrast. In the Southern Hemisphere countries (PNG,

Figure 1. Period of plentiful supply of durian, langsat, mangosteen, pulasan and rambutan in Papua New Guinea, Australia, Indonesia, the Philippines and Thailand.

Durian

Durio zibethinus

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PNG												
AUSTRALIA												
INDONESIA												
PHILIPPINES												
THAILAND												

Langsat

Lanslum domesticum

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PNG												
AUSTRALIA												
INDONESIA												
PHILIPPINES												
THAILAND												

Mangosteen

Garcinia mangostana

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PNG												
AUSTRALIA												
INDONESIA												
PHILIPPINES												
THAILAND												

Pulasan

Nephellium mutabile

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PNG												
AUSTRALIA												
INDONESIA												
PHILIPPINES												
THAILAND												

Rambutan

Nephellium lappaceum

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PNG												
AUSTRALIA												
INDONESIA												
PHILIPPINES												
THAILAND												

Figure 2. Period of plentiful supply of avocado, mango, purple passionfruit, santol and strawberry in Papua New Guinea, Australia, Indonesia, the Philippines and Thailand.

Avocado

Persea americana

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PNG												
AUSTRALIA												
INDONESIA												
PHILIPPINES												
THAILAND												

Mango

Mangifera Indica

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PNG												
AUSTRALIA												
INDONESIA												
PHILIPPINES												
THAILAND												

Purple passionfruit

Passiflora edulis f. edulis/Passiflora spp.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PNG												
AUSTRALIA												
INDONESIA												
PHILIPPINES												
THAILAND												

Santol

Sandoricum koetjape

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PNG												
AUSTRALIA												
INDONESIA												
PHILIPPINES												
THAILAND												

Strawberry

Fragaria sp.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PNG												
AUSTRALIA												
INDONESIA												
PHILIPPINES												
THAILAND												

Figure 3. Period of plentiful supply of grapefruit, lime, mandarin, orange and pomelo in Papua New Guinea, Australia, Indonesia, the Philippines and Thailand.

Grapefruit

Citrus paradisi

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PNG												
AUSTRALIA												
INDONESIA												
PHILIPPINES												
THAILAND												

Lime

Citrus aurantifolia

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PNG												
AUSTRALIA												
INDONESIA												
PHILIPPINES												
THAILAND												

Mandarin

Citrus reticulata

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PNG												
AUSTRALIA												
INDONESIA												
PHILIPPINES												
THAILAND												

Orange

Citrus sinensis

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PNG												
AUSTRALIA												
INDONESIA												
PHILIPPINES												
THAILAND												

Pomelo

Citrus maxima

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PNG												
AUSTRALIA												
INDONESIA												
PHILIPPINES												
THAILAND												

Australia and Indonesia), the main production period extends from November to March. In contrast, the period in the two Northern Hemisphere countries (the Philippines and Thailand) extends from May to September/October (Figure 1). Other examples include durian, mango, santol and mandarin (Figures 1, 2 & 3). Clearly, those crops with marked complementarity in production seasons have the greatest potential for export from PNG to the Singapore and Hong Kong markets.

For other crops, the contrast between locations in the Northern and Southern Hemispheres exists, but is less striking. This is the situation for langsat, pulasan, rambutan (Figure 1), cashew nut and pomegranate (Table 1). In the case of rambutan, the Southern Hemisphere production period is generally different from that in the Northern Hemisphere, but the Australian season overlaps with the season in the Northern Hemisphere countries. For a number of fruits, the season in Australia is extended because they are grown over a wide range of latitudes and different varieties are used that have different production patterns. This is the case for avocado, passionfruit, strawberry and orange (Figures 2 and 3). The season for purple passionfruit in Queensland (December to February) and New South Wales (January to April) is similar to that in PNG (January to April) and Indonesia (November to January) (Table 1). However, the use of hybrid passionfruit species in Australia has now resulted in a continuous production period throughout the year (Beal and Farlow 1984).

Production periods in the Northern and Southern Hemispheres overlap for a number of crops including avocado, breadfruit, custard apple, cherimoya, jackfruit, star apple (caimito) and watermelon (Table 1). For example, the main production period of watermelon is similar in PNG, southern Australia, the Philippines and Thailand with a somewhat longer but similar period in northern Australia (Table 1). In the case of avocado, no simple pattern is apparent (Figure 2). The production periods of galip nut (*Canarium indicum*) in PNG and the pilinut (*C. ovatum*) in the Philippines are similar, that is, May/June to July/August (Table 1). However, the two nuts are products of closely related but different species, so this is not unexpected.

A number of fruit and nut crops are non-seasonal and produce is available year round in all five countries considered. These include banana, coconut and tree cucumber (Table 1). Pawpaw is non-seasonal in all lowland tropical locations, but seasonal in the PNG highlands and sub-tropical New South Wales (Table 1). Similarly, guava production is non-seasonal in the PNG lowlands, northern Australia and Thailand, but seasonal in the PNG highlands, southern Australia, Indonesia and the Philippines. Pineapple production is seasonal in PNG and the Philippines, but non-seasonal in northern Australia, Indonesia and Thailand. This reflects the use of flowering hormones and other chemicals to induce flowering and fruiting in the latter locations.

Some fruit species produce year round in PNG, but are reported as seasonal in some other locations. These include lime and pomelo (Figure 3), bullock's heart, cape gooseberry, five corner (carambola), black raspberry, and soursop (Table 1).

Potential for export to nearby Northern Hemisphere markets

Discussion on the potential for exporting fruit from PNG to overseas markets during their off-season is restricted to species that grow reasonably well in the PNG environment. After processing, nuts can be stored in both an exporting and importing country. Hence, it is not possible to exploit seasonal differences between PNG and potential importing countries for nuts. However, differences in the production period may be important if the nuts were to be processed overseas, for example, cashew.

There are 10 fruit crops which have very different production periods in PNG from those in nearby Northern Hemisphere producing countries. These are durian, langsat, mangosteen, pulasan, rambutan (Figure 1), mango, purple passionfruit, santol, strawberry (Figure 2) and mandarin (Figure 3). Lime and pomelo are non-seasonal in PNG and thus they are available during the out-of-season period in South East Asia (Figure 3).

The best export prospects to Asian markets that exploit seasonal differences are five fruit of

South East Asian origin, that is, durian, langsat, mangosteen, pulasan and rambutan (Figure 1). All of these species grow well in the humid PNG lowlands (Woodhouse 1991); there is a good demand for the fruit in South East Asia; and seasonal differences are marked. Prospects for durian are particularly good as very high prices can be obtained in Asian markets for out-of-season fruit, although airtight containers would be required for air freight because of its strong odour (Watson 1984 a). In contrast, the season in northern Australia and Indonesia is similar to that in PNG for these five species, and hence exports would face potential competition from these two countries. At present there are experimental plantings of all five species on research stations, plantations and in some villages. However, rambutan is the only species that is currently grown for both subsistence use and for sale in PNG, but it is not common outside of the Gazelle Peninsula of New Britain. Substantial development is needed before exports could occur.

Mango is in season in PNG during the off-season in Northern Hemisphere Asian countries making it a potential export crop (Figure 2). It grows well in parts of the lowlands, including coastal Central and Western Provinces, the Markham Valley, the north coast of the Huon Peninsula, Siassi Island and parts of the Gazelle Peninsula. However, the quality of most existing trees is poor as they have been grown from seedlings, although cultivars that produce good quality fruit are available at research stations. Any exports from PNG have to compete with those from the well established Australian industry in which the production period is extended because of the wide latitudinal range over which mango is grown (Alexander, no date).

The season for purple passionfruit in the PNG highlands is different from that in Thailand (Figure 2). However, the non-seasonal lowland yellow passionfruit (*Passiflora edulis f. flavicarpa*) is grown in South East Asian countries and the non-seasonal hybrid species are likely to be grown there in the future. Hence, prospects for exploiting seasonal differences in passionfruit for exporting are poor.

Santol is another crop that has a different producing season in PNG from that in Northern Hemisphere Asian countries (Figure 2). It is not

grown by villagers in PNG. It is a minor crop with limited demand in Asia and it is unlikely that sufficient demand exists to justify development as an export crop (Watson 1984 b, Woodhouse 1991).

The season for strawberry in the PNG highlands occurs during the off-season in the nearby Northern Hemisphere countries (Figure 2). Hence, there may be possibilities for a specialist producer to export strawberries to Singapore or Hong Kong. However, severe packaging, handling and transport constraints would have to be overcome if this delicate fruit was to be exported successfully.

A number of citrus fruit may have potential as exports to out-of-season Asian markets, but other considerations suggest that the potential is not great. Mandarin production is markedly seasonal in PNG and elsewhere (Figure 3). Mandarin is well suited to intermediate altitude locations (800-1400 m) in PNG (Bourke and Tarepe 1982) and there is a large unsatisfied demand for mandarin within PNG. If the existing small industry expands so that domestic demand is satisfied, PNG fruit could be exported to Asian markets during their off-seasons. However, fruit would be in competition with that from the established Australian industry.

Oranges produce reasonably well in the intermediate altitude zone and lower highlands in PNG (Bourke and Tarepe 1982) but fruit colour is poor and there are a number of major pest problems. Given that fruit from Australia and elsewhere is available virtually year round, that oranges are oversupplied on world markets and that the quality of fruit from sub-tropical and temperate environments is superior to that from PNG, there are no realistic prospects of exporting oranges.

Both lime and pomelo are non-seasonal in the PNG lowlands, but production is seasonal in South East Asian countries (Figure 3). Both have potential as export crops during the off-season in the nearby Northern Hemisphere. However, the constraints of high production and transport costs in PNG may negate any seasonal advantages that PNG producers have.

Potential for export to nearby Southern Hemisphere markets

Prospects for exporting fresh fruit from PNG to Australia during the off-season are poor for a number of reasons:

1. The production season in PNG for many fruit is similar to that in Australia. Within Australia, the overall production season is long, because production occurs over a wide range of latitudes and a mix of cultivars is used with different seasonal patterns.
2. The Australian market is well supplied with high quality fruit for much of the year. The February to April period is glutted with a good range of temperate and sub-tropical fruit, but fruit is in poorer supply between August and October (Cull 1984:11). This pattern is similar to that in PNG.
3. Quarantine restrictions in Australia are strict and high standards are set for pest and disease levels in imported fresh food. For example, entry is prohibited for all 15 fruit species for which we present data in Figures 1, 2 and 3, although no risk assessment has been conducted on many of these fruits and the restrictions could be reviewed (Louise Vanmeurs, Department of Primary Industries and Energy, Canberra, pers. comm.).

A comparison of production periods between PNG and Australia indicates that the following fruit exhibit different patterns: langsat, avocado, mango, raspberry, grapefruit and pomelo. Their potential as exports is now considered.

Langsat production appears to commence a little earlier in PNG than in northern Australia (Figure 1). Langsat is not produced commercially in PNG and is a very minor fruit in Australia. If plantings in Australia expanded beyond Queensland to other locations such as the Northern Territory or the north west of Western Australia, the Australian producing period would possibly be extended. The prospect exists that fruit could be exported to Australia before the Australian season commences but this is remote.

Avocado has potential for export to Australia, if only the production season is considered. Har-

vesting in Australia extends throughout most of the year, but supply is light in January, February and March, which is potentially the period of peak demand (Whiley 1984:73). The period of poor supply in Australia coincides with the period of peak production in the PNG lowlands and highlands (Figure 2). However, quarantine restrictions prevent the entry of fresh avocado into Australia because of the presence of sun blotch virus in PNG which is absent in Australia. In addition, the Australian market requires fruit with a high oil content, but PNG fruit generally have a lower oil content (M. Levett, UPNG, pers. comm., 1993). Overall, there is little prospect of exporting avocado from PNG to Australia.

The mango production season in PNG is similar to that in northern Australia (Figure 2). The season in Central Province usually commences before that in the Markham Valley and the Gazelle Peninsula, although there is considerable year-to-year variation in the start and duration of the season (Bourke *et al.* in press). If trees in Central Province were treated chemically to induce consistently earlier flowering so that fruit matured in September and October, then the prospect exists for fruit to be exported to Australia before the main Australian harvest starts in October and November.

In the PNG highlands, black raspberry is produced year round, but only minor quantities are marketed. Commercial types of red raspberry are not grown in PNG, although fruit of two indigenous self-sown red raspberry (*Rubus moluccanus* and *R. rosifolius*) are occasionally eaten (Tarepe and Bourke 1982:96). In Australia the production period for red and black raspberries extends from October to June (Table 1) with peak production in late December and January (Menzies 1986). There may be potential for exporting red or black raspberry from PNG to Australia between July and November but severe packaging, handling and transport constraints for this highly perishable fruit would have to be overcome. Freezing the fruit may overcome these constraints.

The grapefruit season in PNG commences earlier than in Australia (Figure 3). Latitude apparently influences the start of the season, as it does for mango in Australia (Alexander, no date). The grapefruit season commences in February in PNG, May in Queensland and June in

New South Wales (Table 1). There may be prospects for specialist growers in the PNG highlands or the intermediate altitude zone to export grapefruit to Australia before the Australian season commences.

Pomelo is non-seasonal in the PNG lowlands and weakly seasonal in northern Australia. As with grapefruit, specialist growers could export pomelo to the Australian market during the off-season. However, the off-season is only four months long and pomelo is a very minor fruit. Hence, prospects for exporting pomelo are not good.

Both lime and strawberry are available in PNG when they are unavailable from New South Wales producers (Table 1). However, Queensland producers supply the southern markets when local fruit is not in season. Thus, there is no potential for exporting these fruits from PNG to Australia during the off-season.

CONCLUSIONS

This preliminary study has indicated that a number of fruit species have potential to be exported from PNG to fill market niches during the non-production period in certain overseas markets. The most promising are durian, langsat, mangosteen, pulasan and rambutan for export to Northern Hemisphere Asian urban markets. Demand for durian in particular is good and further investigation is warranted. The PNG production period of langsat is a little different from that in northern Australia and it may be possible to export langsat to Australia. However, it is a poorly developed and minor crop in both countries and export potential is probably limited.

A number of other fruit have some potential to fill market niches but other constraints reduce the possibility that export markets could be developed. Mango could be supplied during the off-season to Northern Hemisphere Asian markets. If PNG production could be made to start earlier, mango could be exported to the Australian markets before the northern Australian season commences. Lack of suitable germplasm in PNG and handling problems reduce the potential. Strawberry and raspberry from PNG could fill market gaps in Asia and Australia respectively, but handling constraints are so severe that this is probably unrealistic. Avocado from PNG

could fill a gap in the Australian market, but quarantine restrictions, handling problems and fruit quality make this possibility highly improbable.

A number of citrus species may have potential for export. These are mandarin, lime and pomelo to Northern Hemisphere Asian markets and grapefruit and pomelo to Australia. As with all other fruit species, considerable development of the PNG industry is required before this could eventuate.

The next stage in an investigation of the potential for exporting fruit from PNG to overseas markets is research in the target markets regarding demand, price and quarantine restrictions for each species. Numerous other factors need to be considered before investment in an industry could be recommended, including production costs, packaging, handling constraints and transport availability.

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REFERENCES

- ABURU, K. (1982). Notes on some fruit and nut trees in the Keravat area of East New Britain. In: *Proceedings of the Second Papua New Guinea Food Crops Conference*. Eds. R.M. Bourke and V. Kesavan. Department of Primary Industry, Port Moresby. pp. 101-122.
- ALEXANDER, D.McE. (no date). The Mango in Australia. Commonwealth Scientific and Industrial Research Organisation, Melbourne. 28 pp.
- BEAL, P.R. and FARLOW, P.J. (1984). Passifloraceae. In: *Tropical Tree Fruits for Australia*. Ed. P.E. Page. Queensland Department of Primary Industries, Brisbane. pp. 141-149.
- BEATTIE, B.B. (1982). Seasonal availability of fresh fruits. Agfact H1.5.9. NSW Department of Agriculture, Sydney.
- BOURKE, R.M., CAMAROTTO, C., D'SOUZA, E.J., NEMA, K., TAREPE, T.N. and WOODHOUSE, S. (in press). Production patterns of 180 food crops in Papua New Guinea. *Research Bulletin No. 54*. Department of Agriculture and Livestock, Port Moresby.
- BOURKE, R.M. and TAREPE, T.N. (1982). Locations for commercial citrus production in Papua New Guinea. *Harvest*, 8(4):147-155. Department of Primary Industry, Port Moresby.
- CORONEL, R.E. (1991). *Canarium ovatum*. In: *Plant Resources of South-East Asia*. Number 2. Edible Fruits and Nuts. Eds. E.W.M. Verheij and R.E. Coronel. Pudoc, Wageningen.
- CULL, B.W. (1984). Factors important in assessing the potential of tropical tree fruit species for Australian horticulture. In: *Tropical Tree Fruits for Australia*. Ed. P.E. Page. Queensland Department of Primary Industries, Brisbane. pp. 10-19.
- DEPARTMENT OF AGRICULTURAL EXTENSION (1987). Fruits in Thailand. Bangkok. 48 pp.
- EVANS, B. (1991). The production, processing and marketing of ngali nuts (*Canarium spp.*) in Solomon Islands. Unpublished report, Dodo Creek Research station, Ministry of Agriculture and Lands, Honiara. 37 pp.
- FLEMING, E. and HARDAKER, B. (1992). Prospects for niche marketing in South Pacific island nations. *Pacific Economic Bulletin*, 7(1):21-26.
- HANLON, D.W.G., CHACKO, E.K. and BAKER, I.W. (1989). Northern Territory horticulture development prospects. *Agricultural Science*, 2(3):42-45.
- HENTY, E.E. (1982). Some nut-bearing plants in Papua New Guinea. In: *Proceedings of the Second Papua New Guinea Food Crops Conference*. Eds. R.M. Bourke and V. Kesavan. Department of Primary Industry, Port Moresby. pp. 78-85.
- IBPGR. (1980). Fruits [in Indonesia]. International Board for Plant Genetic Resources, Rome. 127 pp.
- ISLAM, N. (1990). Horticultural exports of developing countries: past performances, future prospects, and policy issues. *Research Report 80*. International Food Policy Research Institute, Washington.
- MENZIES, A.R. (1986). Raspberry growing in New South Wales. Agfact H3.1.46. NSW Department of Agriculture, Sydney. 8 pp.
- NSW DEPARTMENT OF AGRICULTURE. (no date a). Fresh is Best. *Poster Series numbers 2 and 8*. New South Wales Department of Agriculture, Sydney.
- NSW DEPARTMENT OF AGRICULTURE. (no date b). New South Wales Fruit. New South Wales Department of Agriculture, Sydney. 39 pp.
- O'HARE, P. and VOCK, N. (1990). Growing Macadamias in Queensland. Queensland Department of Primary Industries, Nambour. 35 pp.
- STEPHENSON, R.A. (1991). Tropical fruit production in the southern hemisphere. *Paper presented at the ISHS International Symposium on Tropical Fruits*, Pattaya, Thailand, May 1991.
- TAREPE, T. and BOURKE, R.M. (1982). Fruit crops in the Papua New Guinea highlands. In: *Proceedings of the Second Papua New Guinea Food Crops Conference*. Eds. R. M. Bourke and V. Kesavan. Department of Primary Industry, Port Moresby. pp. 86-100.
- WAIT, A.J. and JAMIESON, G.I. (1983). The cashew. *Farm Note F206/NOV 83*. Queensland Department of Primary Industries, Brisbane.
- WALTER, A. and SAM, C. (1993). A variety collection of nut trees and fruit trees in Vanuatu. Institut Français de Recherche Scientifique pour le Développement en Coopération, *Notes Techniques* No 15. ORSTOM, Port Vila.
- WATSON, B.J. (1984 a). Bombaceae. In: *Tropical Tree Fruits for Australia*. Ed. P.E. Page. Queensland Department of Primary Industries, Brisbane. pp. 45-50.
- WATSON, B.J. (1984 b). Meliaceae. In: *Tropical Tree Fruits for Australia*. Ed. P.E. Page. Queensland Department of Primary Industries, Brisbane. pp. 92-99.
- WATSON, B.J. (1990). Opportunities for exotic fruits. *Agricultural Science*, 3(5):21-25.
- WHILEY, A.W. (1984). Lauraceae. In: *Tropical Tree Fruits for Australia*. Ed. P.E. Page. Queensland Department of Primary Industries, Brisbane. pp. 70-77.
- WOODHOUSE, S. (1991). Asian Fruit in Papua New Guinea. In: *Proceedings of the Papua New Guinea First International Fruit Conference*. Ed. A.A. Bala. Department of Agriculture and Livestock, Port Moresby. pp. 161-168.
- VERHEIJ, E.W.M. and CORONEL, R.E. Eds. (1991). *Plant Resources of South-East Asia*, Number 2. Edible Fruits and Nuts. Pudoc, Wageningen