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Biographical Notes

Dorothy Shaw is a plant pathologist. After six years post graduate work at the University of Sydney she worked in Canada for two years on cereal pathology. In 1955 she initiated and then developed the Plant Pathology Service in Papua New Guinea. She remained there as Chief Plant Pathologist until 1976 and later in Brisbane was Consulting Pathologist to Papua New Guinea for two years. Since then she has been carrying out special research with facilities provided at Department of Primary Industry, Brisbane. She has travelled extensively in the tropics and in 1977 was Food and Agriculture Organisation Consultant at Nicaragua after the outbreak of coffee rust in Central America.

Michael Bourke is a tropical agriculturalist. He was employed by the Papua New Guinea Department of Primary Industry as a research agronomist between 1970 and 1977 in the Lowlands and between 1978 and 1983 in the Highlands. His studies have concentrated on food crops and especially on village farming systems. His main research experience with Papua New Guinea coffee has been as a component of integrated cropping systems in village agriculture, including coffee's contribution to village cash income and possible conflicts between coffee and subsistence food production. He is presently completing a doctoral thesis in the Department of Human Geography at Australian National University entitled 'Taim Hangri: Variation in Subsistence Food Supply in the PNG Highlands'.

Simon Bell is an economist. He has undertaken research work in the Economics Department in the Research School of Pacific Studies at Australian National University, mainly on trade issues between Australia and Southeast Asia. In early 1982 he took up a position with the Department of Finance (Papua New Guinea) working on a wide range of macroeconomic issues. His involvement with the coffee industry in Papua New Guinea has been through his work with the Coffee Industry Board on the coffee stabilization fund. After four years in Papua New Guinea, Simon has recently joined the National Centre for Development Studies, at Australian National University where he is currently producing 'The Pacific Economic Bulletin'.

Barry Shaw has a PhD in Economics from the Australian National University and is Course Director at the National Centre for Development Studies, specialising in training of government officials from Asia and the Pacific. He worked in Papua New Guinea from 1973-1979 and was First Assistant Secretary for Primary Industry. He has a great deal of experience in the rural economics of Pacific countries including Papua New Guinea and Southeast Asia. He recently authored a monograph 'Agriculture in the Papua New Guinea Economy' for the Institute of National Affairs, Port Moresby.

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FOREWORD AND ACKNOWLEDGEMENTS

The recent outbreak of coffee rust was first reported in the Western Highlands of Papua New Guinea on 30th April 1986. Dr. B. Shaw of the National Centre for Development Studies organised three consultants (Mr S C Bell, Mr R M Bourke and Dr D E Shaw) to prepare a report for the Australian Development Assistance Bureau (ADAB) on the implications of the introduction of this potentially debilitating disease. The report was submitted to ADAB within ten days of the initial outbreak being reported in Papua New Guinea. This working paper is an edited version of the original report with the additional assistance of Dr B. Shaw. It has not been updated to account for developments since 10 May 1986. Since then, coffee rust has been reported in the Madang Province (Simbai Valley, Bundi and Teptep areas), East Sepik Province, West Sepik Province (Lumi area), the Eastern Highlands (Asaro Valley) and another location in the Western Highlands (Nebilyer Valley). Further outbreaks are inevitable.

Immediately the outbreak was reported the Papua New Guinea Department of Primary Industry and industry personnel in Papua New Guinea began implementing measures designed to slow the spread of coffee rust and to reduce its impact. With the approval of the Secretary of the Department of Primary Industry in Papua New Guinea, the authors had telephone conversations with a number of key staff including Mr R Doery, Mr P Barker and Dr B N Muthappa. Their willingness to discuss the issue when they were under intense pressure of work is greatly appreciated. Acknowledgement is also made of assistance given by personnel in the Bank of Papua New Guinea, the Department of Finance and Planning, the Taxation Office in Port Moresby and the Papua New Guinea Coffee Industry Board in Goroka.

Chapter 1

Introduction

Coffee leaf rust is the worst disease of coffee and one of the worst plant diseases in the world. It caused the collapse of the Arabica coffee industries in Sri Lanka, the Philippines and Indonesia. While many countries are now living with coffee rust, it has entailed considerable inputs of money for control programs, breeding and other research in relation to the disease.

Coffee leaf rust (Hemileia vastatrix) was reported in the Baiyer River area of the Papua New Guinea highlands on 30 April 1986 and has since been reported in other coffee growing areas. Its economic and social impact on an area where coffee is such a major source of income could be very considerable.

This paper brings together the agricultural, economic and social aspects of the disease within the context of the coffee industry of Papua New Guinea.

Coffee is a tropical tree crop of which two types are grown commercially in Papua New Guinea:

(i) Arabica (Coffea arabica) is mainly grown in Papua New Guinea in the highlands, over an altitudinal range of 600 to 2100 metres but with the bulk of the crop grown between 1000 and 2000 metres and with the greatest concentration between about 1400 and 1800 metres. Arabica accounts for 95 per cent by volume of the Papua New Guinea crop, and most of the Arabica

is produced in the highlands region. Arabica is very susceptible to coffee rust.

(ii) Robusta (Coffea canephora) is grown at lower altitudes in the lowlands and coastal areas and accounts for about 5 per cent of production. It is more resistant to coffee rust.

Unless specified otherwise (e.g. coffee as an industry, coffee as an export item, or Robusta coffee), all further discussion refers to Arabica coffee.

Coffee trees commence bearing two to three years after field planting. Production increases for several years thereafter. The economic life of trees is dependent on a number of factors, but 20 to 25 years is probably typical. Coffee 'beans' (which are contained in a small fruit termed a 'cherry') are the economic produce of coffee trees. After harvest, the outer skin of the cherry is removed mechanically or by hand and the beans are washed and fermented in a factory or in small containers. This product is termed 'parchment' coffee. Another skin is removed in a factory to produce 'green beans' which are exported. Some village coffee is sold in the cherry form, but most is processed to the parchment stage before sale. Plantation coffee is sold as green bean or parchment. Although the crop is harvested year round, production is heavily concentrated between May and September. The coffee industry is dominated by 266,511 smallholders who produce about 75 per cent of the crop. They are concentrated in the highlands, which account for 43 per cent of the rural population of Papua New Guinea. Coffee exports (K95 million in 1984) have accounted for over 41.6 per cent of agricultural exports and about 14.2 per cent of total commodity exports (all means of

the last five years). The likely impact of coffee rust disease must be assessed not only because of coffee's significance for the economy as a whole but because such a high proportion of the population depends on it as a major source of cash income.

Chapter 2

Coffee in the national economy

Coffee is the most important agricultural export for Papua New Guinea; coffee exports are only exceeded by copper and gold. But unlike minerals, its production is spread over almost half of the rural population.

Employment in the coffee industry

Employment in the coffee industry is predominantly that of self-employed smallholders in villages. Formal sector employment is largely on plantations and in coffee processing, transporting and exporting. No estimate of total formal employment is available, but 12,517 citizens were reported as employed in highlands plantations (which are mainly coffee) in 1982 (National Statistical Office 1985).

Employment in the smallholder, self-employed sector, however, is far more important. The 1980 census estimated that 266,765 households - a total of 48 per cent of the total number of village sector households in Papua New Guinea - grew coffee. This participation rate is exceeded only by pig raising (58 per cent) and food crop selling (53 per cent). But in the three major producing provinces of the highlands - Western and Eastern Highlands and Chimbu - household involvement in coffee is higher than 80 per cent and is a very important source of cash income.

As well as direct employment in the coffee industry, there is also employment in activities that support the coffee industry, especially in the highlands where it has a substantial effect on overall employment.

Structure of the industry

Smallholder production increased steadily up to the late 1970s while estate production remained relatively static (see Table 1). In 1982/83, smallholder production accounted for 75 per cent of total coffee production compared with 66 per cent in 1974. Smallholder production shows considerable variation with price: the Department of Primary Industry estimates that in years of low prices, 10 to 20 per cent of coffee remains unharvested. The department also estimates that smallholdings yield 0.5 to 1 tonne per hectare under average management (and much less under poor management), while estates yield an average of about 2 tonnes per hectare.

Although smallholder production is increasing, there is concern by the Papua New Guinea government that in some areas, replanting of senile trees is not being done at a rate sufficient to ensure sustained production. In areas where coffee is a more recent crop, such as the Southern Highlands and Enga, production is increasing. Estate production has stagnated and appears to have been falling in recent years.

The government has recently encouraged the establishment of (approximately) 20 hectare blocks on traditional land on which groups can borrow money under Clan Land Usage Agreements or by mortgage after the land has been surveyed and excised from traditional ownership.

Table 1 Structure of the coffee industry - production by smallholdings and largeholdings (tonnes of green bean)

	Smallholders		Plantations		Total
	Tonnes	%	Tonnes	%	Tonnes
1974/75	25,186	66	12,955	34	38,141
1975/76	29,910	69	13,133	31	43,043
1976/77	27,203	70	11,616	30	38,819
1977/78	31,504	70	13,511	30	45,015
1978/79	..		..		49,585
1979/80	34,919	68	16,440	32	51,359
1980/81	35,683	70	15,511	30	51,194
1981/82	29,595	72	11,247	28	40,842
1982/83	41,117	75	13,735	25	54,852

Sources: Papua New Guinea Department of Primary Industry and industry sources.

Management and extension advice is purchased from management companies. These smaller estates are beginning to come into production and total national coffee production is expected to increase. About 200 of these blocks have been planted since 1980.

In 1983, there were 178 estates producing coffee, covering 7463 hectares. Most estates are owned by Papua New Guineans or Papua New

Guinea organizations; about two-thirds of estates are less than 50 hectares.

Production by province

In the 1982/83 coffee season 85 per cent of coffee production came from the three highlands provinces of Western Highlands, Eastern Highlands and Chimbu (Table 2). The five highlands provinces accounted for almost 90 per cent of all coffee production in that year.

At an average factory door price of K1440 per tonne (green bean basis), and allowing 10 per cent for transport and buyers' margins, 1982/83 gross coffee income per smallholder in the three major producing provinces averaged K337 per annum.

Export revenue

Over the five years to 1984, coffee receipts averaged K95 million or 42 per cent of agricultural exports and 14 per cent of total exports. Coffee has made a very substantial contribution (Table 3) to the relatively healthy balance of payments position Papua New Guinea has enjoyed over the last several years.

Table 2 Coffee production by province - 1982/83
(tonnes green bean)

Province	Households growing coffee		Production (tonnes)			% of total production	Production per household (Kg)[a]
	Number	%	Smallholder	Plantation	Total		
Producing mainly Arabica:							
Western Highlands	44,361	83	11,492	8,997	20,489	37.6	259
Eastern Highlands	48,197	89	12,731	4,218	16,949	30.9	264
Chimbu	35,516	80	9,071	-	9,071	16.5	255
Morobe	32,373	66	1,845	420	2,265	4.1	57
Enga	11,499	31	1,650	21	1,671	3.0	143
Southern Highlands	19,962	41	658	55	713	1.3	33
Madang	16,669	43	445	11	456	0.8	27
Central	4,834	22	84	-	84	0.2	17
Gulf	2,744	22	32	-	32	0.1	12
Subtotal	216,155	60	38,008	13,722	51,738	94.5	176
Producing mainly Robusta:							
East Sepik	28,463	63	1,804	-	1,804	3.3	56
Northern Province	8,296	69	784	9	793	1.4	95
West Sepik	8,546	34	378	-	378	0.7	44
Milne Bay	4,391	16	137	-	137	0.2	31
West New Britain	228	2	5	4	9	0.0	22
Western Province	432	3	1	-	1	0.0	2
Subtotal	50,356	37	3,109	13	3,122	5.7	62
Total	266,511	48	41,117	13,735	54,852	100.0	154

[a] Smallholder production per coffee growing household in province.

Sources: Papua New Guinea Department of Primary Industry, industry sources and 1980 census.

Table 3 Value of coffee and other exports from Papua New Guinea, 1980-85 (K million (fob[a]))

Coffee as per cent	Value of coffee exports	Value of agricultural exports	Coffee as % of agric. exports	Value of total exports	% of total exports
1980	118.6	238.1	49.8	691.8	17.1
1981	74.2	174.8	42.4	565.9	13.1
1982	77.8	174.4	44.6	570.4	13.6
1983	94.7	231.5	40.9	687.4	13.8
1984	110.7	380.6	29.1	823.7	13.4
1985					
Mar qtr	14.0	65.1	21.5	180.9	7.7
June qtr	35.5	99.1	36.8	233.5	15.2
Sept qtr	42.6	94.6	45.0	246.2	17.3

[a] fob free on board

Source: Bank of Papua New Guinea, various issues, Quarterly Economic Bulletin.

Importance of the coffee industry to government revenue

The coffee industry contributes to government tax receipts directly through the export tax on coffee exports and through the taxation of companies and individuals who earn income from the industry. Many associated industries, such as transport and other services, are also wholly or partially dependent on coffee. The industry also contributes through indirect taxes such as import duties and excise taxes.

An export tax is levied on most agricultural exports, including coffee, at 2.5 per cent of free on board (fob) value. In the 1986 budget estimates, K3.0 million was expected to be raised on coffee exports of K120 million.

Company tax collections on coffee from companies associated with the coffee industry are estimated at about K13.5 million or 25 per cent of total company tax collections in 1986. This excludes the mining companies whose tax revenues flow through the Mineral Resources Stabilization Fund.

Non-company income taxes derived from coffee were estimated at about K7.4 million or 5 per cent of total personal income taxes in 1986.

Almost all imports coming into Papua New Guinea are subject to the General Import Levy (GIL) which is currently 7.5 per cent. However, some imports enter Papua New Guinea at rates of import duty which are substantially in excess of the GIL rate. For example, cars are imported with an import duty of 110 per cent plus the GIL. The Chief Collector of Taxes estimates that the overall rate of import duties is 20 per cent. Imports generated by the coffee industry would attract these import duties.

Further indirect taxes would be collected from taxes on goods such as fuel, beer, cigarettes and soft drinks. The Chief Collector estimates that half of total excise tax collections would originate from the highlands. Assuming 70 per cent of these to come directly and indirectly from coffee the relative contribution of the coffee industry would be around K22 million in the 1986 budget.

In addition to the effects mentioned above, coffee incomes would have a strong multiplier effect throughout the highlands and the national economy. The contribution of the coffee industry to total tax

collections is estimated in Table 4 using the 1986 budget (which assumes export receipts from coffee of K120 million) as its base.

Table 4 Estimated contribution of the coffee industry to internal revenue (K million)

	1986 budget	Estimated contribution of the coffee industry
Export tax	14.0	3.0
Personal income tax	147.0	7.4
Company tax	54.0	13.5
Import duty	139.0	11.0
Excise tax	64.0	22.0
Others	151.7	-
Total	569.7	56.9

Source: Papua New Guinea, (1986b), Estimates of Revenue and Expenditure and authors' estimates.

According to these estimates, in an average year, the coffee industry would contribute in total around 10 per cent of total budgeted internal revenue in the current year. But the calculations for the coffee industry include mainly 'first round' effects, and exclude further internal revenue generated by the additional government and private sector spending which might be generated by coffee expenditure. A more detailed estimate would require the use of a sectoral model of the Papua New Guinea economy.

The 1986 budget was drawn up on the basis of a 1986 coffee price of only K2373 per tonne. It now appears that the 1986 price will be closer

to K4000 per tonne. Consequently, total internal revenue should be higher in 1986 as a result of increased revenue derived from the coffee industry.

Coffee prices and recent trends

Table 5 gives international coffee prices over the period 1970 to 1985 in both current and constant (1980) terms together with Papua New Guinea export prices.

Increased prices in the latter part of the 1970s were essentially the result of a frost in Brazil in 1975.

Table 5 Annual average coffee prices 1970-86

Year	New York (all grades) (US cents per pound) Current price	Constant[a] Price (1980 prices)	Papua New Guinea (K/tonne fob Lae Y-Grade)[b]
1970	50.53	144.79	..
1971	44.66	121.36	..
1972	50.40	126.00	..
1973	62.16	133.97	880
1974	67.95	120.27	915
1975	72.48	115.41	981
1976	141.96	222.86	2,113
1977	229.09	327.27	3,478
1978	155.00	192.55	2,298
1979	169.50	185.86	2,438
1980	150.71	150.71	2,316
1981	115.82	115.24	1,518
1982	125.62	126.76	1,857
1983	127.94	132.58	1,930
1984	141.24	148.99	2,280
1985	133.47	139.03	2,931
1986 June	193.55		4,000 (est)

[a] Deflated by the World Bank's Manufactured Unit Value Index (MUV).

[b] The majority of Papua New Guinea's coffee exports are 'Y-grade'.

Sources: International Monetary Fund, various issues; Bank of Papua New Guinea, various issues; Papua New Guinea Government, 1984.

Coffee prices have remained relatively stable since the mid 1970s when compared to other tropical agricultural export crops. This has been, in part, due to the activities of the International Coffee Organization. The average of K2000 per tonne over the past ten years approximates the long-term trend price expected by the International Bank for Reconstruction and Development (World Bank).

Price increases towards the end of 1985 resulted from the news that the 1986 Brazilian crop was expected to be 45 per cent below normal as a result of a drought. Papua New Guinea average prices jumped to K4000 per tonne, and the International Coffee Organization suspended quotas in February 1986. The drought has since broken and there does not appear to have been significant tree loss; Brazilian production is expected to recover substantially next year.

Papua New Guinea will benefit from the high price not only for current production but will be able to export some or all of its coffee stocks. The Papua New Guinea Coffee Industry Board expects that over 54,000 tonnes will be sold this season for a return of about K200 million.

The share of the coffee export price received by producers in Papua New Guinea is among the highest of coffee producing countries with large numbers of smallholders. Factory door prices for coffee parchment have consistently been between 70 and 80 per cent of export prices. Prices are rapidly transmitted to growers through a marketing system which is highly competitive and efficient. There are eight firms (most of which are owned by papua New Guinea) licensed to export by the Coffee Industry Board.

Some areas of lower population density have a poor marketing infrastructure and production in these areas has been declining in recent years.

The Coffee Stabilization Fund

The Coffee Stabilization Fund was established to stabilize producer prices over the coffee price cycle and, as a component of macroeconomic price stabilization policy, to overcome demand fluctuations which affect a small open economy dependent upon primary commodity exports. Similar funds exist in the cocoa, copra and oil palm industries.

The Coffee Stabilization Fund has a dual role: besides stabilizing prices, it is also used as a coffee stockpiling fund in years when production exceeds the quotas set by the International Coffee Organization.

Under the rules of the International Coffee Organization (Appendix 2) when prices are low, coffee producing countries are allocated quotas for sale to member consuming countries of the International Coffee Organization in order to maintain prices. Additional coffee can be sold outside the International Coffee Organization market to non-member countries, but generally at much lower prices. The stockpiling function of the fund was to purchase coffee stocks, outside of quota sales, which could otherwise only be sold at unacceptable prices. To date, the fund has not been used to purchase stock, instead, stabilization fund money has been used to top up the price of sales to non-member countries.

The Coffee Stabilization Fund built up strongly over the period 1976 to 1979, when coffee prices were very high (Table 6).

Table 6 Coffee Stabilization Fund Balances, 1975-1985
End of year balance (K million)

1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
3.7	6.8	46.4	63.6	83.8	94.9	90.3	92.1	85.3	82.1	98.0

Source: Bank of Papua New Guinea, various issues.

Levies are collected when prices are above a long-term moving average and bounties paid to growers when prices are below the long-term average. Neither bounties nor levies have been collected or paid over the past two years and the fund built up to its current level of K98 million.

During the current high prices, levies should theoretically be collected and credited to the Coffee Stabilization Fund, since prices are well above long-term moving average prices, but this has not occurred because:

(i) The government and the Coffee Industry Board (which manages the Coffee Stabilization Fund) have not decided how to allocate funds between the two functions of the fund, and have not determined what is an appropriate bounty/levy; and

(ii) The stabilization funds and the Coffee Stabilization Fund in particular have attracted an undue amount of political interest. Industry groups and government officials have to date managed to avoid having these funds put to uses other than for their primary, legislated purpose. Nonetheless,

this has made the Coffee Industry Board and the government sensitive about collecting further revenue into a fund which already has almost K100 million and which may therefore become a more enticing political target.

Chapter 3

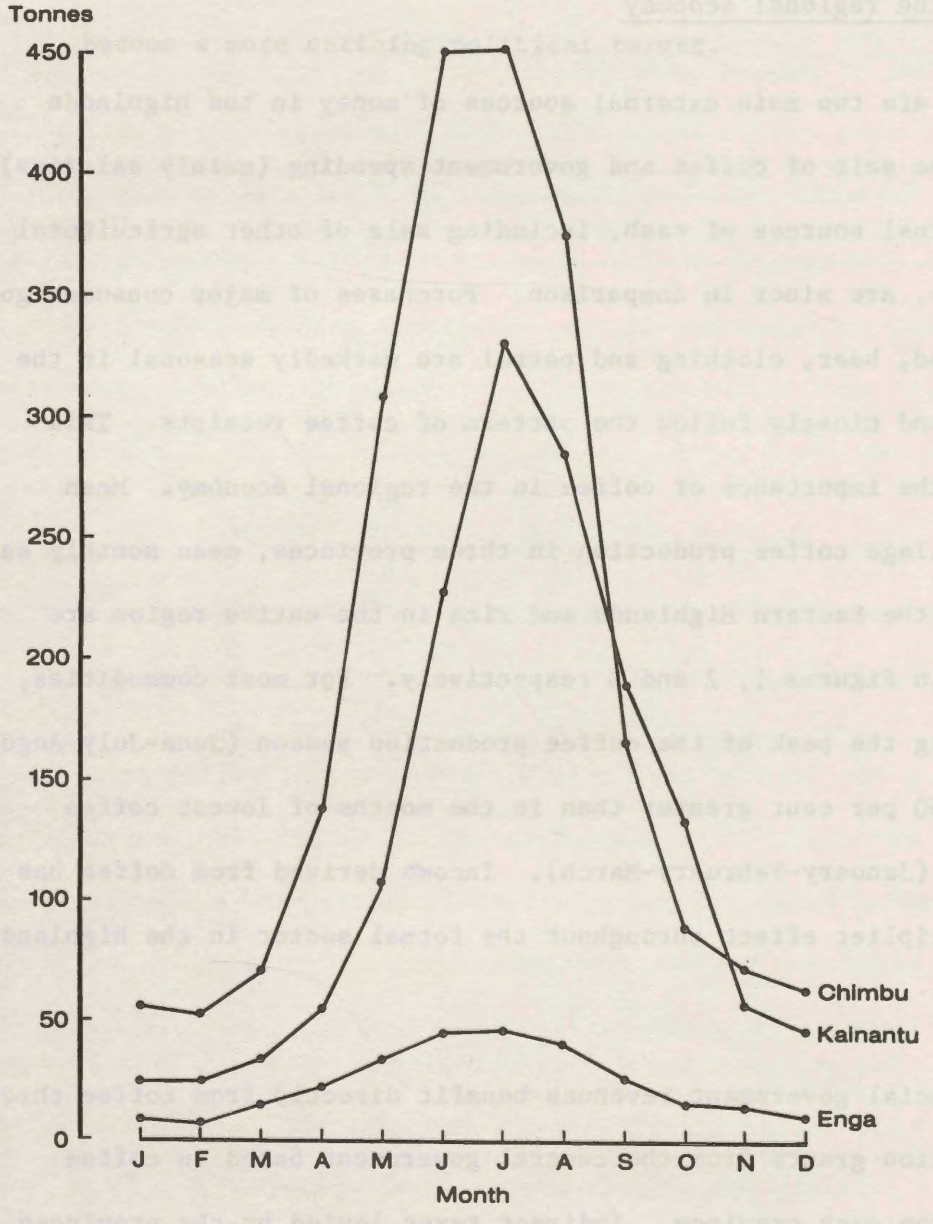
Coffee in the highlands regional and village economies

Coffee in the regional economy

There are two main external sources of money in the highlands region: the sale of coffee and government spending (mainly salaries). Other external sources of cash, including sale of other agricultural commodities, are minor in comparison. Purchases of major consumer goods such as food, beer, clothing and petrol are markedly seasonal in the highlands and closely follow the pattern of coffee receipts. This indicates the importance of coffee in the regional economy. Mean monthly village coffee production in three provinces, mean monthly sales of beer in the Eastern Highlands and rice in the entire region are presented in Figures 1, 2 and 3 respectively. For most commodities, sales during the peak of the coffee production season (June-July-August) are about 50 per cent greater than in the months of lowest coffee production (January-February-March). Income derived from coffee has a strong multiplier effect throughout the formal sector in the highlands towns.

Provincial government revenues benefit directly from coffee through the derivation grants from the central government based on coffee receipts from each province. Indirect taxes levied by the provinces also depend on the impact of coffee receipts on overall expenditure. Most provincial governments tax beer at 6 to 9 toea a litre and the Eastern Highlands, for example, applies a general retail sales tax of 3

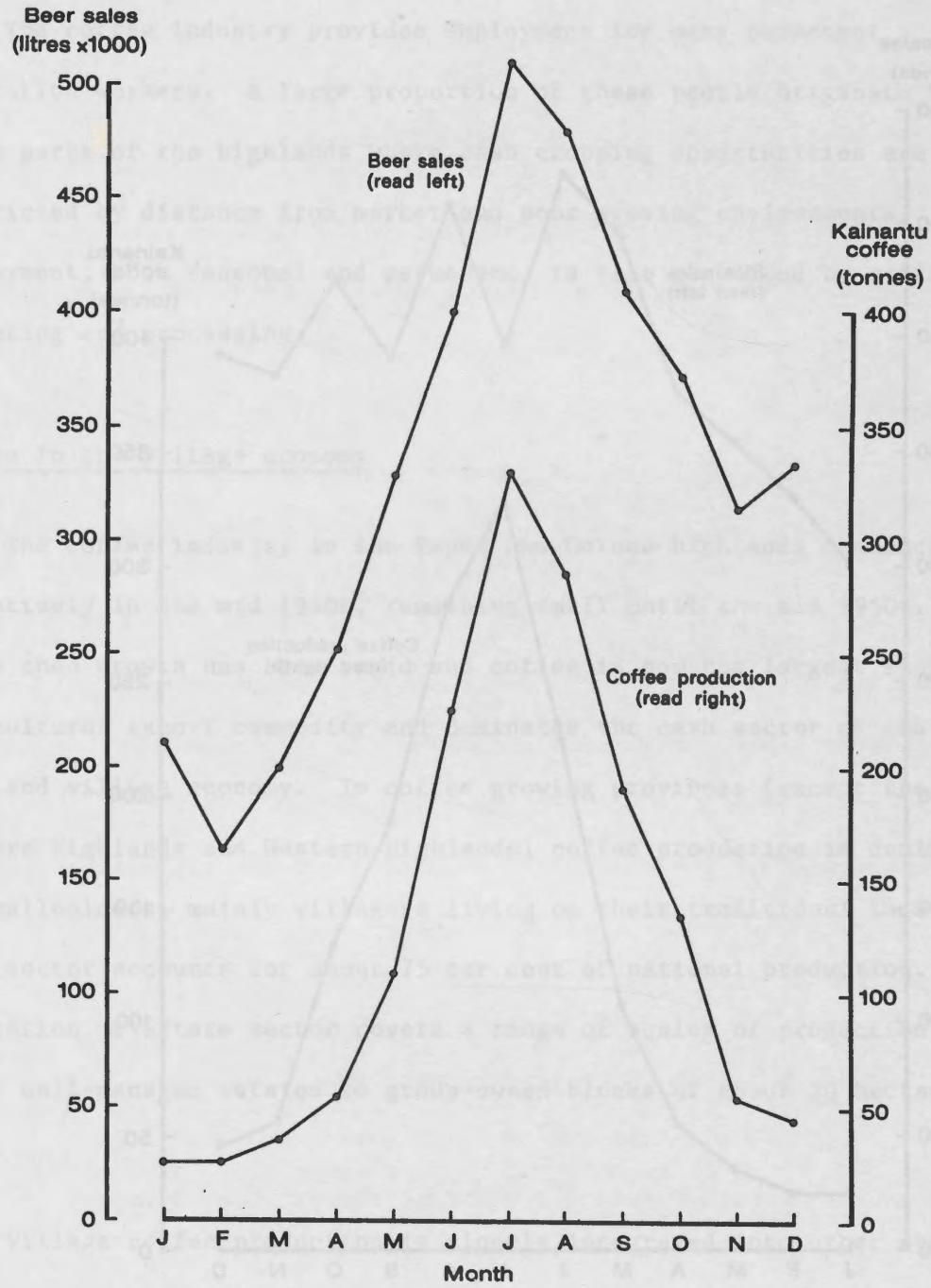
Figure 1: Mean Monthly Village Coffee Production in Chimbu (1971-76), Kainantu area (1974-83) and Enga (1970-79) (tonnes green beans)



Sources: Chimbu Coffee Cooperative figures from D Howlett and CIB, Goroka.

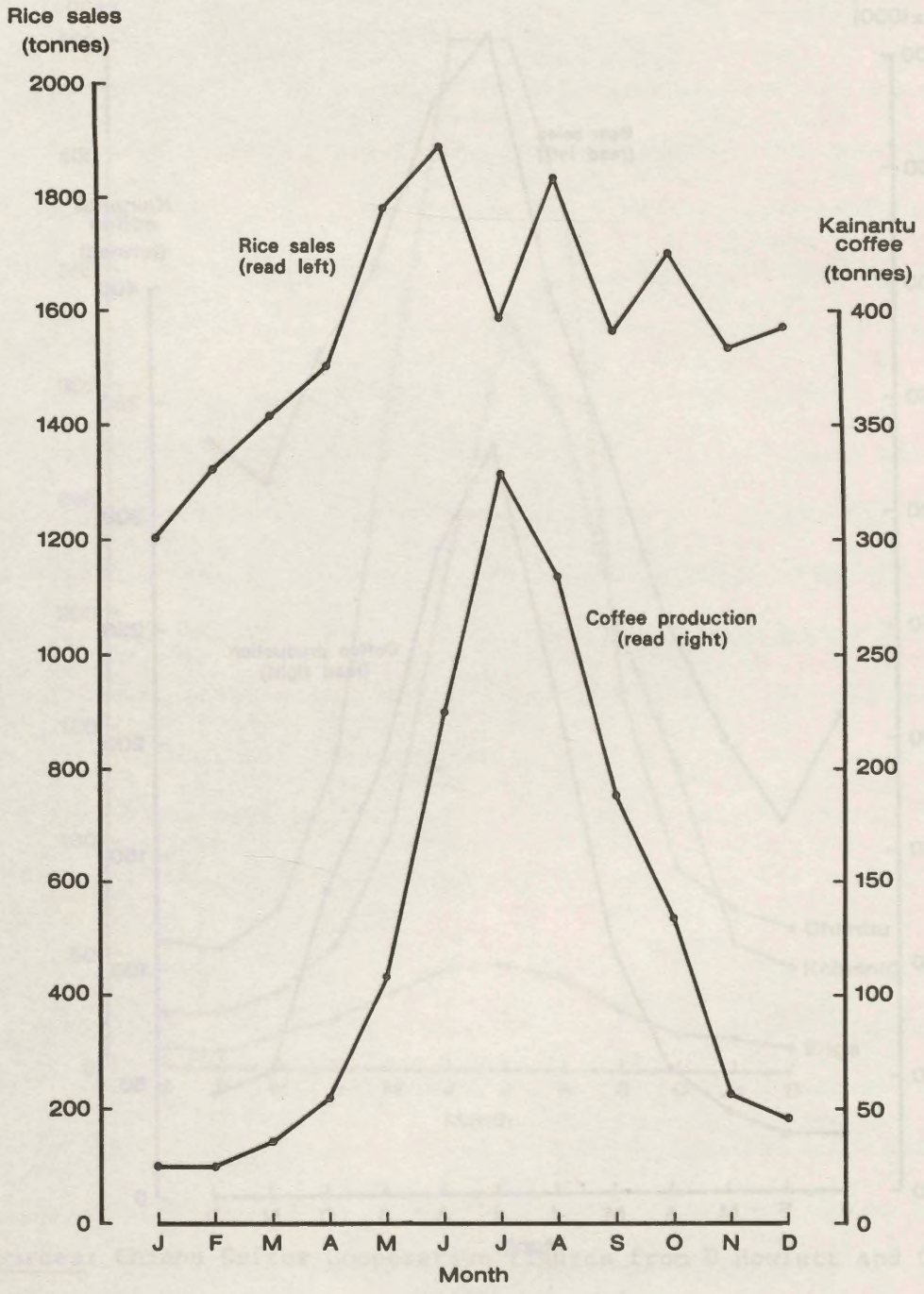
Kainantu (KKB factory and Ramu Coffee Ltd) from two factories and CIB, Goroka. Enga (Waso Coffee Factory) from Carrad (1982:152).

Figure 2: Mean Monthly Beer Sales, Eastern Highlands (1979-84) and Village Coffee Production, Kainantu Area (1974-83)



Source: Beer data: E.H.P. Provincial government

Figure 3: Mean Monthly Rice Sales, Highland Terminals (1977-84) and Village Coffee Production, Kainantu Area (1974-83)



Source: Rice data: Rice Industries Ltd, Lae.

per cent. Changes in coffee receipts therefore have an impact on provincial government revenue in the region.

The coffee industry provides employment for many permanent plantation workers. A large proportion of these people originate from those parts of the highlands where cash cropping opportunities are restricted by distance from market and poor growing environments. Employment, both seasonal and permanent, is also generated by coffee marketing and processing.

Coffee in the village economy

The coffee industry in the Papua New Guinea highlands commenced tentatively in the mid 1940s, remaining small until the mid 1950s. Since then growth has been rapid and coffee is now the largest single agricultural export commodity and dominates the cash sector of the highland village economy. In coffee growing provinces (except the Eastern Highlands and Western Highlands) coffee production is dominated by smallholders, mainly villagers living on their traditional land. This sector accounts for about 75 per cent of national production. The plantation or estate sector covers a range of scales of production from large well-managed estates to group-owned blocks of about 20 hectares in area.

Village coffee production is closely integrated into other economic activities such as subsistence and cash food production and pig raising, but is the major source of cash income for most highland villages in the coffee zones (below 2100 metres). Most of the smallholder crop is produced without any cash input, except for purchase or hire of hand

pulpers and multipurpose tools such as spades. Herbicides and fertilizers are used by only very small numbers of growers. The main labour input is for harvesting, processing and selling the crop.

The average village holding is about 0.2 hectares and is likely to be spread over several plots intermixed with other crops.

Coffee is very well suited to highland social systems. It yields under a wide range of management levels, even those with minimal inputs. Returns per unit labour input have generally been higher than for alternative export crops such as tea or chilli. It is perhaps the only agricultural export commodity in Papua New Guinea to provide returns to labour of village producers comparable to (or higher than) the rural minimum wage at all prices over the past decade.

Coffee marketing in the Papua New Guinea highlands is quite efficient; buyers are independent or linked to coffee processors and buy for cash on the roadside or come to the village. Sellers can also sell direct to processors. Competition is considerable, and growers have consistently received about 60 to 70 per cent of the export price.

For most highland villagers, coffee is the source of much or most of their cash income: from the sale of their own coffee; from long-term wage labour on coffee plantations; and from short-term wage labour during the coffee season. Money from coffee has provided a major impetus to improvements in highlands village living standards and has been an important source of funds for investment expenditure in the region. While there has been a great deal of comment on some of the more visible (and negative) social and economic effects of coffee

expenditure, such as alcohol consumption and road accidents, there have been widespread benefits. Coffee income has paid for a large proportion of the education costs for village children. People are now able to buy food that is high in protein and concentrated calories such as tinned fish, rice and food cooked in animal fat. Traditional highland villagers' diets were low in protein and concentrated energy. A recent major survey in Chimbu Province has indicated that children in (1981 figures) are taller and heavier than their parents' generation (in 1956 figures), implying less child malnutrition. The children's better nutritional status was attributed to the widespread consumption of high protein and concentrated energy foods. It is likely that these findings apply throughout the highlands.

The supply of subsistence food fluctuates from year to year and is sometimes greatly reduced by climatic factors such as drought, frost or excessive rain. Traditional strategies of coping (such as migration) have been replaced in recent years by increased purchases of store food when food from village gardens is in reduced supply. In 1984 when a widespread food shortage affected the highlands, rice sales in the region were 23,000 tonnes, compared with 17,000 tonnes in 1983 and 19,000-20,000 tonnes for the period 1980 to 1982 (figures by communication with Rice Industries Ltd, Lae). In recent years, the impact of partial crop failure in subsistence gardens has been greatly reduced in the highlands because of the availability of high quality imported food and money to purchase it.

The importance of coffee in the village economy is illustrated with data from three villages in Table 7:

(i) Barabuna Village is typical of many highland villages with coffee sales accounting for 75 per cent of village cash income with a small amount of cash from wage labour and other sources.

(ii) Asiranka village is more typical of those adjacent to towns where there are more employment opportunities. Coffee provides 30 per cent of cash income and wage labour 57 per cent.

(iii) Upa Village in a remote area of the Southern Highlands typifies a village where coffee has been grown more recently, where transport is more difficult and where a high proportion of village income is from temporary out-migration of labour. Coffee sales provided only 28 per cent of cash income, but coffee labour (mainly in the Western Highlands) accounted for 58 per cent, bringing coffee-related income to 86 per cent of cash income. (These figures are for 1983 when there was a strong demand for casual labour.)

Table 7 Cash income by source in three villages in the Papua New Guinea highlands (Kina)

Source	Barabuna village, EHP, 1977	Asiranka village, EHP, 1983	Puit clan, Upa village, SHP, 1983
Sale of coffee	23,600	29,000	3,500
Casual labour picking coffee	1,600	1,000	7,100
Other wage labour	3,500	55,000	100
Sale of fresh food/pig meat	1,500	6,000	800
Other	3,100	7,000	800
Total	33,300	98,000	12,300
Cash income/resident/year	76	233	55
Percentage of cash income:			
Coffee sales	71%	30%	28%
Coffee sales plus coffee-related labour	76%	31%	86%

Notes: 1. Barabuna is in the Kainantu District of the Eastern Highlands. Asiranka is also in the Kainantu District but is closer to wage employment opportunities. Puit clan is part of Upa Village, Nembi Plateau in the Nipa District, Southern Highlands. The Nembi Plateau is a remote area and the cash income pattern is typical of many remote communities.

2. Data for 1984 are also available for Asiranka and the Puit clan. The Asiranka figures do not differ greatly (K219 per resident per year); but the income for Puit clan members was very much reduced in 1984 (K19 per resident per year) because of the unavailability of the major source of cash income - seasonal wage labour on coffee plantations in the Wahgi Valley.

3. EHP - Eastern Highlands Province; SHP - Southern Highlands Province.

Sources: The Barabuna data are from Grossman (1984:196); the Asiranka and Puit clan data are from Bourke (forthcoming).

Chapter 4

Coffee leaf rust and its effects

The disease

The coffee leaf rust, which was reported in Papua New Guinea on 30 April 1986, has been confirmed as caused by the fungus Hemileia vastatrix. (A second rust disease of coffee due to another species of Hemileia is at present still confined to Africa.)

The disease caused by Hemileia vastatrix is the worst disease of coffee. It has caused tremendous economic losses in some coffee growing countries, as outlined later in this chapter. It occurred in Papua New Guinea in 1965 in an isolated area growing a little coffee, but was eradicated.

Symptoms of the disease

The first symptoms of the disease are faint yellow spots on the undersurface of the coffee leaves. Within one or two days of the appearance of the spots, yellowish-orange powder (the spores of the fungus) is produced on the spots on the undersurface of the leaves. The area of leaf affected by a single infection is at first only a few millimetres in diameter, but each spot quickly increases in size to over 2 centimetres in diameter. In heavy infections many spots may occur on each leaf and in very heavy infections the spots may coalesce until the whole leaf is covered. The upper surface of the leaf shows a yellow

area in the region of the infection, but as no spores are produced on the upper surface, it does not become powdery. Leaf tissue in the centre of each infection eventually dies and becomes brown. Millions of spores are borne on each heavily infected leaf, so that an enormous number of spores is produced on all the leaves of all infected coffee bushes.

Damage to the coffee bush

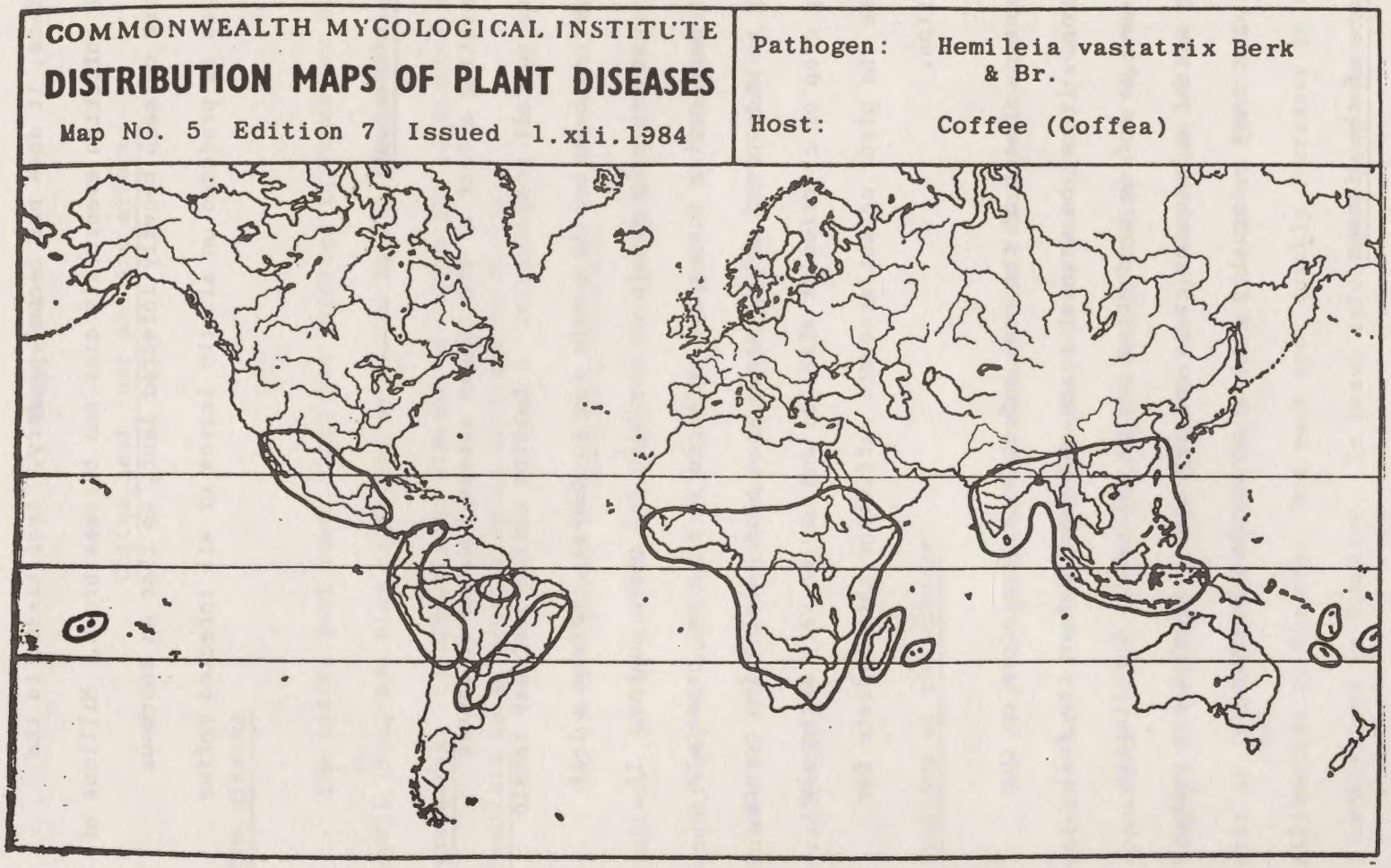
The devastating effect of the fungus arises because it causes infected leaves to fall prematurely. A healthy coffee leaf may remain on a healthy coffee bush for 12 months (as in Kenya), whereas a leaf infected with rust may only remain on the bush for three months. If many leaves of many coffee bushes are infected in an area, premature leaf drop will be widespread and severe. When this defoliation occurs, the succeeding crop of cherries is affected and may be very seriously reduced because the plant cannot generate sufficient carbohydrate for cherry production.

The production impact of the rust infection is therefore on the next year's crop. It may be several years, however, before the full impact of disease on coffee production can be assessed. Defoliation will adversely affect subsequent crops and repeated epidemics may weaken trees so much that they eventually produce no worthwhile crop.

World occurrence of the disease

The fungus is widespread in almost all the coffee-growing countries of the world. Papua New Guinea was free from rust until the present

Figure 4: World Distribution of Coffee Leaf Rust (at December 1984)
(Infected Areas Shown by Heavy Black Outlines)



outbreak, and the rust is still absent from Australia, which has an infant coffee industry in North Queensland. The world distribution of the fungus to late 1984 is shown in Figure 4 . The distribution of the fungus, like its coffee host, is mainly confined to the tropical zone.

Losses caused by the disease in other countries

Sri Lanka (as Ceylon) was the first country seriously affected by coffee rust. Within five years of its first observation there in 1869 it had spread throughout every plantation on the island. The average yield before its appearance had been about 560 kilograms per hectare. By 1878 the yield was down to 250 kilograms per hectare and plantations were soon abandoned. One effect of the collapse of the coffee industry in Ceylon was that England changed from a predominantly coffee-drinking to a tea-drinking nation.

Java was the next to suffer after Ceylon. Before the rust arrived that country was producing 60,000 tons annually; five years later it was 40,000 tons and in another five years it was 20,000 tons. Very little Arabica coffee is now cultivated in Indonesia.

In the Philippines, coffee was the most important export before the arrival of the rust there in 1883. A few years later the plantations were abandoned. A few other examples are as follows: in 1910 the fungus reached New Caledonia and after only two years half the crop was lost; in Uganda the losses in 1960 were estimated at 30 per cent of the crop; and in Kenya, coffee rust caused serious defoliation in the 1400-1600 metres altitude zone. Although less rust was generally experienced in the higher altitude zones in Kenya (because of the lower temperatures),

serious rust infection (over 40 per cent) was recorded in 1981 at higher altitudes in an unsprayed plot of coffee.

The fungus was first recorded in South America in Brazil in 1970. After the outbreak the rapid development of the disease to epidemic proportions led to almost complete defoliation in the centre of the infected area within a few months. The fungus spread rapidly in 18 months along a front 1000 kilometres long, and reached Argentina, Paraguay, Bolivia, Equador and Colombia within nine years.

The disease was first reported in Central America in Nicaragua in 1976. Although it was contained in the originally infected area for several years by a rigorous eradication program, the arrival of the fungus in El Salvador meant that the program could not be maintained. It has now spread to Guatemala, Honduras, Mexico and Costa Rica.

The fungus

The spores of the fungus are minute, kidney-shaped, orange coloured and are only about 0.025 to 0.04 millimetres long.

The spores germinate at night or in dim light if water is available in the form of rain or dew. After germination, the threads issuing from the fungus enter the plant through breathing pores (stomates) on the undersurface of the leaves. Once inside the leaf the fungus multiplies and after a time (called the 'incubation period') begins to produce many millions of new spores on the undersides of the infected leaves.

The length of this incubation period varies according to coffee variety and may differ in various regions. In Sri Lanka, for example, it is 14 days, in South India about 16 days and is from four to seven weeks in Kenya. The incubation period under shade in Minas Gerais in Brazil was reported in 1981 to be 29-62 days.

The determination of the length of the incubation period, and of the time taken for the maximum production of spores on any spot, is an important area of research and needs to be investigated in any region affected for the various varieties being grown. This is necessary because the length of the incubation period affects the amount of inoculum (spore load) to be expected at any time and therefore influences the optimum timing of chemical spray applications.

Unfortunately, the coffee rust fungus is mutable, that is, it is able to produce different types of the fungus by mutation, and possibly by other means. These different types, called 'races', look the same under the microscope, but have the ability to infect types of coffee trees which were previously resistant. Over 30 races of the fungus have now been identified in the world. One of the most widespread races is race II which, with race I, was found in Papua New Guinea in 1965. India had at least six races some years ago and ten races have been recorded in Timor. The outbreak in Brazil in 1970 was caused by race II, but eleven distinct races were identified in the state of Sao Paulo in Brazil between 1970 and 1980. Not only have many of the Arabica varieties lost their resistance to rust, but races attacking the resistance of Robusta coffee were found for the first time in Brazil in 1979.

Plants affected

Only plants in the genus Coffea are affected by this fungus. There are many species of Coffea in the world, but Coffea arabica (Arabica) and Coffea canephora (Robusta) are practically the only ones commercially grown. In Papua New Guinea the coffee is about 95 per cent Arabica; in Brazil (to mention one other country only) about 99 per cent of the coffee was Arabica in 1977. Since then, Brazil's Robusta production has increased to almost 20 per cent.

Unfortunately for all the coffee-producing countries of the world, the most rust-susceptible coffee is Arabica. Robusta coffee, although more resistant than Arabica and preferring lower altitudes, is not used commercially on the same scale as Arabica because the quality of the liquor made from it is considerably inferior to that from Arabica. Robusta is mainly used for soluble (instant) coffee.

Crosses between the rust-susceptible Arabica and the more resistant Robusta coffee, and other Coffea species, have been investigated at various institutions in the world for some decades. Hybridization has been difficult, however, because Arabica coffee has a different number of chromosomes from Robusta. Even when crossing is achieved, the progeny are often infertile, may have small beans and the liquor is of a lower quality than that of pure Arabica. Hybridization is discussed later in this chapter.

In some countries, indigenous Coffea species occur and these may also carry the fungus. There are no indigenous species of Coffea in Papua New Guinea. But in dealing with the 1965 outbreak it was found

that some of the cultivated Arabica had escaped into the rainforest and surrounding bush from plantations and smallholdings. If this has occurred in the highlands and elsewhere near the present infected area, these 'escapes' could also carry the rust and act as sources of infection (by producing new crops of spores) for cultivated coffee.

Spread of the fungus

The minute spores of the fungus fall on to lower leaves and may be splashed by rain or dew drops on to surrounding leaves. The spores can also be passively carried on persons, their clothing and goods, and on machines, vehicles or animals. They may also be blown short distances on detached leaves in high winds, or carried as single spores in air currents.

While some of the inoculum (spores which may cause infection) can be reduced by various actions such as chemical treatments there is a component (as is evident from the preceding paragraph) which cannot be totally eliminated while any coffee remains infected.

The presence of inoculum, factors affecting the amount of it present at any time in the various areas, and the agents of its spread must be continually kept in mind in immediate and long-term programs to combat coffee rust. The factors affecting the severity of the disease and its spread are discussed later in this chapter.

Previous occurrence in Papua New Guinea

This disease occurred previously in Papua New Guinea in a small area distant from the main coffee areas in the Port Moresby hinterland, but was completely eradicated in 1965. The eradication campaign cost an estimated A$70,000 but since then nearly A$1,500 millions worth of coffee (at current prices) has been exported with no expenditure required for coffee rust control.

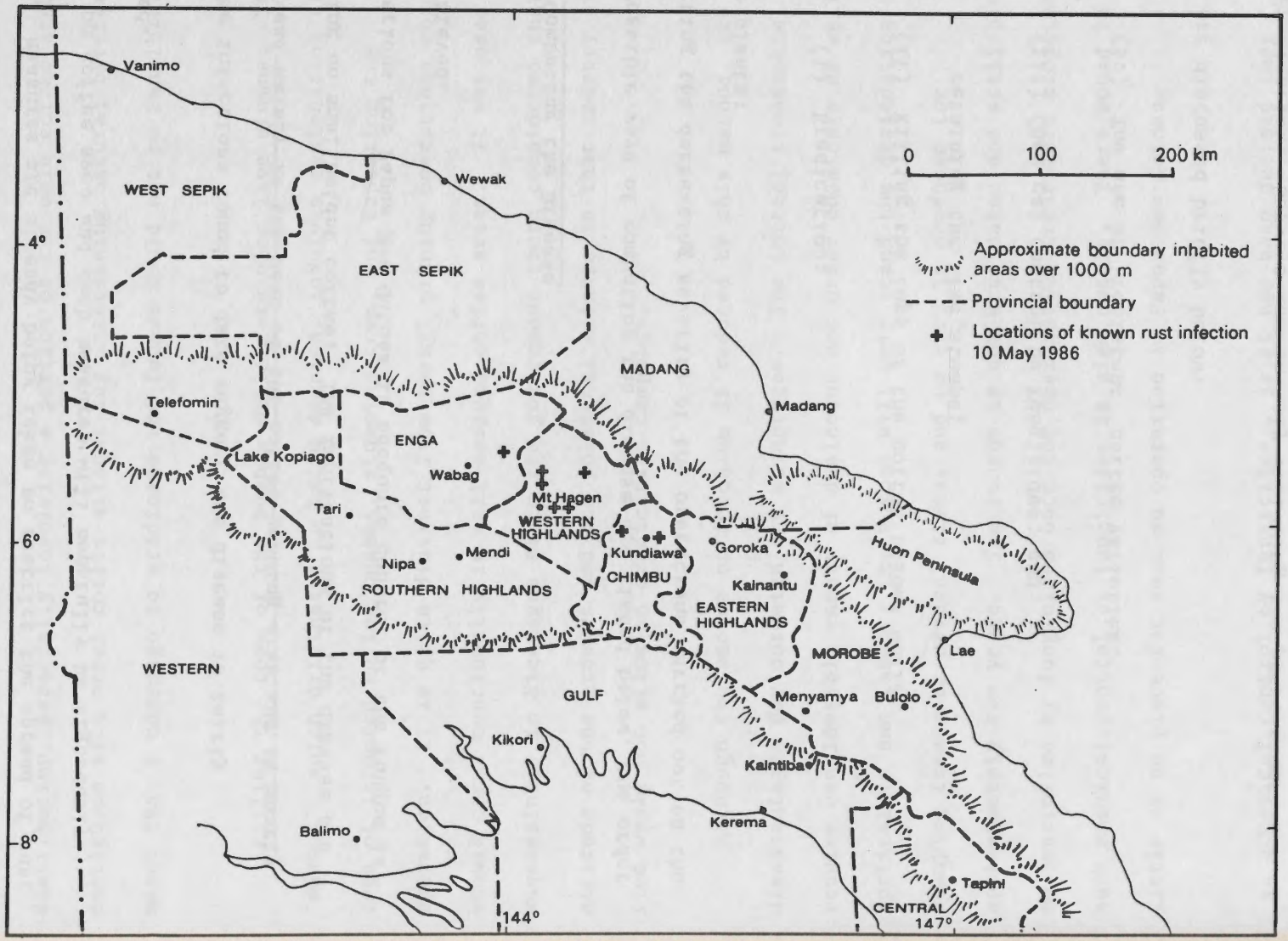
Present outbreak in Papua New Guinea

The present outbreak in Papua New Guinea is in the main coffee areas of the Western Highlands. Infections were first found in the Baiyer River area (where defoliation is already occurring), the Jimi Valley, the Dei Council area in the Wahgi Valley (including some plantation coffee), at two locations in Chimbu and at one location in the Kompiam area in Enga Province. It has also been reported on Robusta coffee in the Lumi area of West Sepik Province. The information available at present indicates that the original outbreak was probably in the Baiyer River area. The location of the infections reported to late May 1986 are shown in Figure 5.

By 10 May, 1986, rust had not been reported in the Eastern or Southern Highlands. Surveys are still being carried out, but further spread is inevitable.

It is not known how the fungus arrived in Papua New Guinea, but it was probably in the form of spores carried inertly and accidentally on travellers or goods, or by wind-blown spores. Indications are that

Figure 5: Inhabited Regions of Papua New Guinea above 1000 Metres Altitude and Locations of Known Coffee Rust Infection (May 1986)



spread within the infected area has been in part through carriage on people. Measures are already being taken to restrict the spread of rust spores on coffee seed and such measures will hopefully be rigorously enforced.

The infections found to date suggest the disease is fairly widespread mainly in the west of the coffee-growing area and is mostly occurring on smallholder coffee. The implications of the disease are very serious for Papua New Guinea if adequate control of the fungus is not achieved.

4.11 Combating the Disease

Possible ways of combating the disease are listed below, the order reflecting the decreasing severity of the operations carried out on the coffee plants:

(i) Eradication;

(ii) Killing the tops of the coffee bushes while retaining the live stumps;

(iii) Chemical control by fungicides; and

(iv) The use of 'resistant' coffee varieties.

These are discussed briefly below.

Eradication. Surveys immediately following the present outbreak of rust revealed that the fungus was already occurring in the Baiyer River Valley, the Dei Council area (in the Wahgi Valley), and at two locations

in Chimbu and one in the Kompian area (in Enga Province). Such a distribution, especially involving a portion of the main coffee area and contiguous with other coffee without any intervening natural barriers, meant that a campaign to eradicate the fungus would not be feasible.

Killing the tops of the bushes while retaining live stumps. This 'method', which originated in Latin America, involves desiccating the tops of infected coffee bushes, stumping them, and repeating the operation. It is quite distinct from normal pruning operations which should occur continually in well-managed coffee areas. It was used successfully in Nicaragua since the government there considered that the attitude of the growers and the political climate in that country at the time would not allow an eradication campaign.

Although the amount of inoculum is reduced by this method, its disadvantages may outweigh any advantages. The initial treatments require considerable inputs of desiccant and other chemicals as well as applicators and labour; the bushes will only stand the desiccating and stumping treatment several times, and no crop is produced for approximately two years. The fungus is not eradicated and still has to be controlled by fungicides once the desiccating treatments stop, and such chemical control by fungicides is also costly. There would be little or no place for such an operation in Papua New Guinea.

Chemical control by fungicides. As it has been decided that eradication of the present outbreak would not be feasible, a control program with the application of fungicides is being put into operation.

It must be recognized however that even if chemical control measures were immediately undertaken (as is happening), this would only slow the spread of the fungus and reduce the inoculum, and perhaps save a lot of next year's crop of cherries. The ultimate spread of the fungus to all the coffee-growing areas of Papua New Guinea is probably inevitable.

This means that if coffee bushes are to be protected in the future, chemical control in all infected areas will be necessary. This raises further questions regarding the costs of the measures as against the value of the crop saved at any holding, whether large or small.

Fungicides are of two main types: those such as copper-based and similar compounds (called protectants) which act directly on the fungal spores, and systemic fungicides which act on the fungus through the plant. Protectant fungicides act on the fungus on the leaf surface while systemic fungicides act on the fungus through the plant. Both types require applicators such as backpack sprayers, motorized backpack sprayers or motorized tractor-mounted sprayers.

Copper-based and similar fungicides are cheaper and have proved effective in controlling rust in many parts of the world if correctly applied at the right times. The systemics are initially more expensive, but may have a longer-lasting effect and may therefore be less expensive in the long term. Alternating the systemics with the other types of fungicides is also a possibility.

It must be stressed that there is human risk associated with the use of these compounds if accidentally or deliberately misused. This is

extremely important if sprayers and smallholders cannot read written instructions regarding quantities, risks involved or antidotal measures, or if verbal instructions or information are misunderstood. Bayleton, for example, is sufficiently toxic to require the use of full protective clothing including masks.

Decisions whether to use systemic and/or protectant fungicides (and if so, which ones), where to use them, at what concentrations, and how often, would all be ad hoc at present based on world experience in other countries.

In considering fungicide recommendations in Papua New Guinea, the amount and duration of rain must be especially considered. Arabica coffee is grown in Papua New Guinea in areas with a mean annual rainfall of 1800-5000 millimetres, but the majority of the growers are in the 2000-3000 millimetres per annum zone. As well, there are 12 wet months (mean monthly rainfall of over 100 millimetres) per year in the Western Highlands, Enga and the Southern Highlands; there are 10 or 11 wet months in Chimbu and parts of the Eastern Highlands; and 8 or 9 wet months in most of the rest of the Eastern Highlands (Figure 6).

In Kenya, with one or two dry seasons, four to five applications of protectant fungicide are usually sufficient each year. Even if the incubation period in Papua New Guinea is found to be similar to that in Kenya, protectant fungicides may need to be applied each month during the main growing season between September and May, especially in the continuous rainfall areas of the Western and Southern Highlands, as rain leaches copper from the leaf surfaces.

If one or two applications of a systemic are included in the spraying schedule, this will cut down the number of applications necessary but the cost may be more than five times as high at each application.

If the decision were made by Papua New Guinea to proceed with a control program, very carefully designed experiments would be required for all regions currently, and likely to be, affected by coffee rust. Such experiments would involve comparisons between the efficacy and cost of the different fungicides, the desirability or not of additives, the best times for spraying in relation to rainfall and crop, the most effective concentrations and applications, and the number of times per year spraying would be necessary to give greatest return for the lowest financial outlay.

In all such tests the timing and duration and amount of rainfall must be especially considered. Also, while periods of no rainfall or lower rainfall reduce the amount of fungus produced, it is at such periods that greatest leaf fall occurs. While the leaf fall also reduces the amount of rust inoculum, great stress is then placed on the tree as a producer. The main effect of the premature defoliation caused by the rust will therefore not be evidenced immediately (if chemical controls are not adequate) but will become apparent through reduction or failure of the next season's crop.

If rainfall is more or less fairly constant throughout the year, the defoliation may not be so severe, but the higher rainfall will favour the fungus, since its multiplication is enhanced, and its spores would have ample moisture for germination and penetration. The same

spraying regimes would therefore not be suitable for areas with some drier months, nor for those with more or less continuous rainfall (see Figure 6).

Fungicide trials to cover all these factors must be carefully designed by research scientists. They must also be carefully carried out, and continually and carefully monitored throughout their entire duration by resident research scientists.

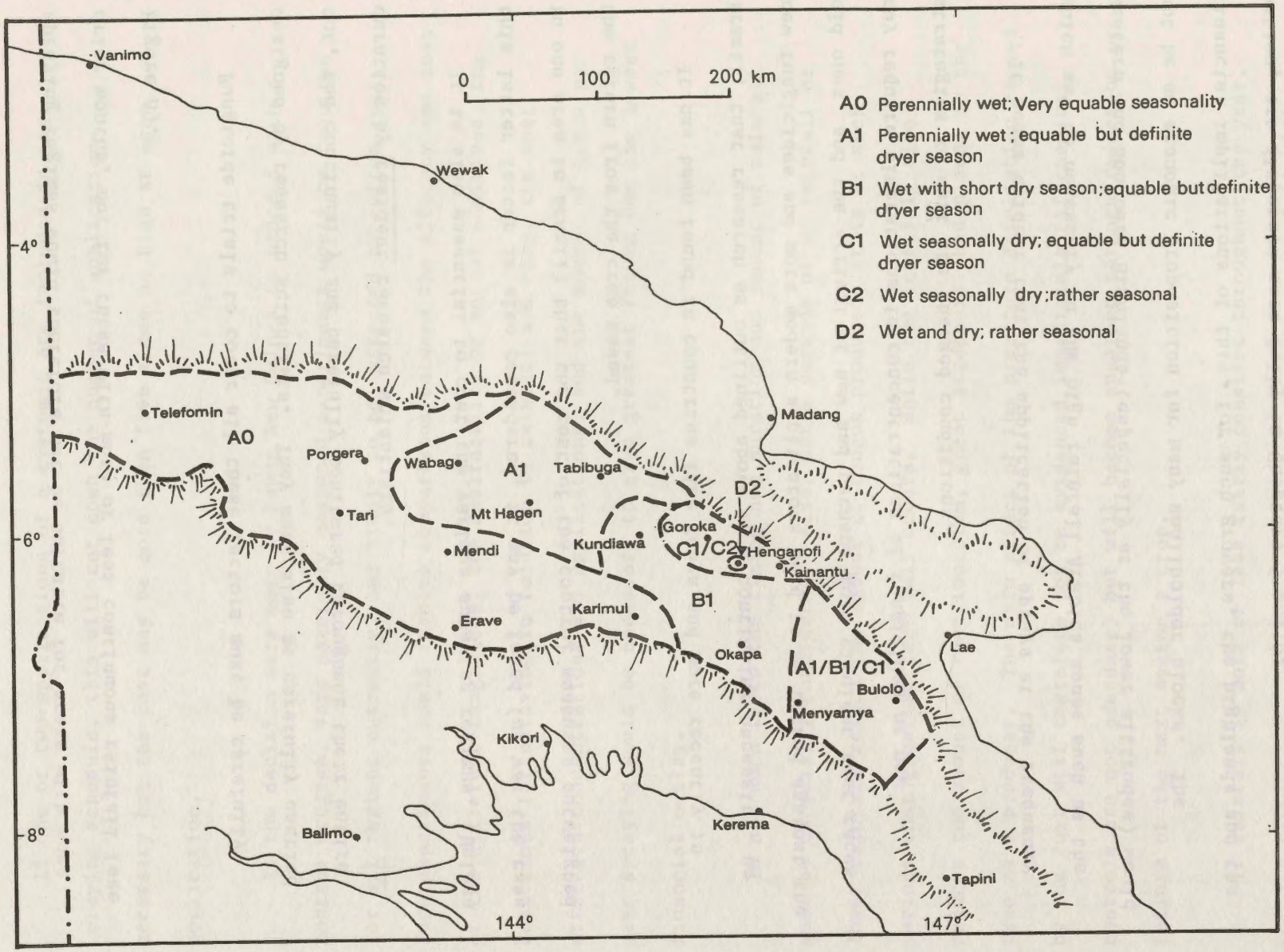
It is also essential to cost the various spraying regimes. Unless this latter factor is also considered, it may be found (as was the case in one area in Brazil) that the cost of the control measures outweighed the return from the crop saved.

It has been found in countries like Kenya and more recently in Brazil, that research as outlined above is a continuing necessity, as new fungicides and more modern applicators need to be tested against the old ones, and the arrival of new and perhaps more virulent rust races may require alterations in concentrations of fungicides or new strategies to suit the changed conditions.

It seems evident that the application of sprays at the frequency which may be necessary in the high rainfall Arabica zones such as the Western and Southern Highlands (especially at the lower altitudes) would not be an economic proposition for many smallholder blocks. The financial implications of this, for such growers, the highlands and the nation, are discussed more fully in Chapters 5 and 6.

The use of 'resistant' coffee varieties. Further investigations into the possible use of 'resistant' varieties would accompany a

Figure 6: Climatic Types in the Papua New Guinea Highlands Based on Rainfall Seasonality



Source: After Bourke, forthcoming.

chemical control program. The use of such varieties is a possible long-term solution, but there are some limitations.

As mentioned previously, Arabica coffee is susceptible to many of the races of the coffee rust fungus. Coffea arabica is a tetraploid (with four sets of chromosomes) and is self-fertile. Robusta coffee (Coffea canephora) is resistant to more races of rust than Arabica. However, it is self-sterile. Also it is diploid, with only two sets of chromosomes.

Coffee breeders have been trying for some decades to cross Arabica coffee with Robusta in order to incorporate the resistances of the latter into the former. Difficulties have occurred, however, because of the difference in the number of sets of chromosomes and in the self-sterility factors in Robusta.

In crosses which have been made, the progeny lack or are low in selfing ability and the liquor is less acceptable than that of pure Arabica. However, doubling of the sets of chromosomes of the Robusta parent has been possible with colchicine treatment. The resulting 'induced tetraploids', as well as rare natural hybrids, have been used in back-crossing programs with Arabicas to try and produce acceptable rust 'resistant' hybrid coffees.

Such breeding programs take many years to come to fruition. Even when produced after years of testing in the laboratory and field, the hybrid seed may still not be available in quantity. Means of mass multiplication (such as vegetative propagation) may have its own

drawbacks, as was found in Kenya where multiplication by seed was later preferred.

The hybrid product (the coffee cherries) may still not (despite repeated backcrossings to the Arabica parent) give liquor as acceptable as that from pure Arabica. Also other alterations in the physiology of the plant may occur, such as lengthening the flowering period. This is not desirable for machine-picked cherries, but may not be a drawback for a hand-picked crop. Yield of cherries may also be lower than the original Arabica parent.

Even such hybrids, selected throughout their development for resistance to the races of the coffee rust prevalent in that country at that time, may 'lose' their resistance in the advent of a new race or races of the fungus to which they are susceptible.

As well as the time taken to develop and test such hybrids, there would also be the time taken to multiply the seed in sufficient quantity for the establishment of nurseries and replacement of old varieties. It must be realized that a new rust race may arise at any time to which the new varieties may be immediately susceptible, unless they possess the more 'durable' types of resistance.

Another factor to be considered is the resistance or susceptibility of any new rust 'resistant' lines to other diseases of coffee. Since Papua New Guinea is free from some other serious diseases of coffee (such as coffee berry disease and bacterial blight) which occur in other countries, the possibility of introducing these (or other) diseases through introduced plant material must always be considered.

Some of the lines incorporating some of the 'resistant' germplasm were imported into Papua New Guinea in the 1960s from overseas institutions. Other 'resistant' lines may also have been imported into Papua New Guinea in more recent years.

A small quantity of seed of more recently produced lines including Catimor selections developed overseas was made available to Papua New Guinea by Australia in 1985 and in March 1986. These five lines were originally imported into Australia in support of Australia's own infant and developing coffee industry on the Atherton Tableland, North Queensland.

Dr H A M van der Vossen examined the existing stock at the Papua New Guinea Coffee Research Institute at Aiyura in 1985. He recommended the build-up of the Catimor lines from Australia (now in their seventh generation) after selection in Papua New Guinea for resistance to rust, compact growth, yield, bean size and liquor quality. If these lines meet these requirements, some seed should be available in a few years, with abundant production of seed a few years later after multiplication. In the meantime, introductions can also be made of other Catimor lines derived from different clones. He stressed that the durability of resistance of the Catimor lines is based on the presence of three to four resistance genes. He further pointed out that although there are indications that the leaf rust fungus is not able to match such resistance, this is no absolute guarantee of permanent resistance.

Australia could perhaps help Papua New Guinea further in the future (as well as reinforcing its own stock of newer coffee lines) by increasing the extent of the present plantings by the Queensland

Department of Primary Industries, in order to multiply the amount of seed available. If this were undertaken, modern mass production methods (including micropropogation) would need to be examined in order to determine the most suitable method of seed production. Multiplication of seed in Australia without the presence of the fungus may be easier than in Papua New Guinea with the fungus. Any new lines, however, would then need to be tested in Papua New Guinea for their behaviour under local conditions.

It cannot be stressed too strongly in relation to hybrid seed or lines with resistance to all or certain rust races that:

(i) they may become susceptible to other races of rust or to other diseases immediately or at some future time;

(ii) they may not give a product with the desirable characteristics of pure Arabica in reference to quality of liquor, size of beans, yield etc.; and

(iii) they still have to be tested in carefully designed and continually monitored experiments by resident research scientists in the various regions in Papua New Guinea to determine their response in growth and performance under the different climatic and soil conditions in each area.

Thus the use of rust 'resistant' varieties, even if research activity is immediately increased many-fold, is not an immediate solution in the short term to the problem of coffee rust in Papua New Guinea.

In view of the known mutability of the coffee rust fungus and also because coffee is a perennial tree crop, the use of rust 'resistant' varieties is not even assured as a long-term solution.

This does not mean, of course, that research into the whole question of the use of 'resistant' varieties and improved lines should not be immediately accelerated. This acceleration should be accompanied by an investigation of the fastest and most effective methods for their multiplication.

Factors affecting the severity of the disease and its spread

Various factors affect both the severity of the disease in any area and its spread to new localities.

Because of the inability to predict the net result of the interplay of the factors affecting spread and rust severity, it is impossible to predict with any accuracy the impact on any particular location. Some comparisons can be made, however, with rust in other countries at similar altitudes and latitudes. A few of the most important factors are briefly discussed below.

Rain. Spores must have water (rain, or dew if of sufficient duration) in order to germinate. Spores are also spread by rainsplash from leaf to leaf and from bush to bush.

Rainfall is high everywhere in the highlands and ranges between 1800 and 5000 millimetres per year. Rainfall increases, while seasonality decreases, from east to west; rainfall is high and somewhat

seasonal in the Eastern Highlands and very high and non-seasonal in the western part of the region (Figure 6).

All locations in the Western Highlands, Enga and the Southern Highlands are perennially wet; that is, the mean monthly rainfall exceeds 100 millimetres per month for 12 months a year (A0 and A1 climatic types, Figure 6). The northern part of Chimbu and the southern part of the Eastern Highlands have one or two drier months per year (B1 climate) and the northern part of the Eastern Highlands has three or four drier months per year (C2 or D2 type climates). Rainfall seasonality varies over short distances in the highland parts of Morobe Province but it is generally similar to the Eastern Highlands.

In most of the Arabica coffee areas in Papua New Guinea, production of spores could occur all the year round under the prevailing rainfall patterns. Most of the other Arabica coffee growing countries of the world have one or two dry seasons per year, during which leaf fall occurs, which in turn reduces the amount of inoculum (spore load) being produced. In Kenya, Brazil and South India for example, coffee is generally grown in locations with five to nine dry months per year (D and E type climates). In higher altitudes in Kenya, for example, the fungus is able to complete only a few generations during the wetter months before growth is restricted by the dry season.

Heavy rain will wash spores from the air. This disadvantages the fungus by preventing those spores being spread further by the wind. If rain washes spores on to coffee bushes, they can germinate and penetrate the coffee, whereas if they land on any other plants or on buildings,

roads etc., the spores will still germinate but will die becuase they can only infect coffee plants.

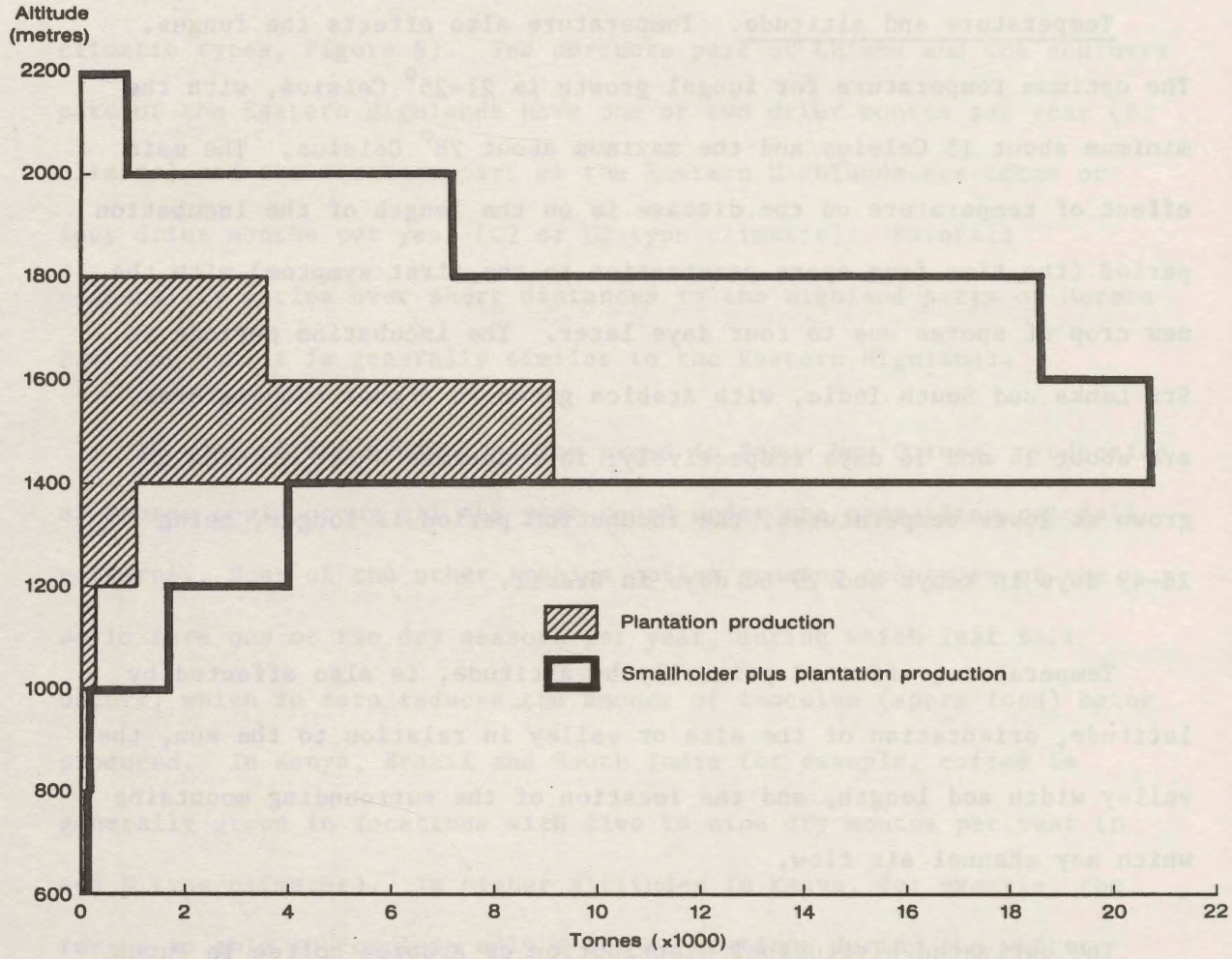
On the whole the high rainfall and continuous rainfall in much of the highlands would tend to favour the fungus.

Temperature and altitude. Temperature also affects the fungus. The optimum temperature for fungal growth is 21-25° Celsius, with the minimum about 15 Celsius and the maximum about 28° Celsius. The main effect of temperature on the disease is on the length of the incubation period (the time from spore penetration to the first symptom) with the new crop of spores one to four days later. The incubation periods in Sri Lanka and South India, with Arabica grown at higher temperatures, are about 14 and 16 days respectively; in countries where Arabica is grown at lower temperatures, the incubation period is longer, being 28-49 days in Kenya and 29-64 days in Brazil.

Temperature, affected primarily by altitude, is also affected by latitude, orientation of the site or valley in relation to the sun, the valley width and length, and the location of the surrounding mountains which may channel air flow.

The estimated altitudinal distribution of Arabica coffee in Papua New Guinea is given in Figure 7. The bulk of the industry is located between 1400 and 1800 metres. Plantation coffee is grown between 1000 and 1800 metres, with the bulk (although not apparent from Figure 7) grown between 1500 and 1700 metres. Smallholder coffee is distributed over a wider altitudinal range (600 to 2100 metres) but concentrated between 1400 and 1800 metres.

Figure 7: Altitudinal Distribution of Arabica Coffee Production in Papua New Guinea



It is probable that in Papua New Guinea rust will be more severe at the lower altitudes with higher temperatures than at the higher altitudes with lower temperatures.

Wind and high mountains. Spores may be carried by wind many kilometres and for thousands of metres into the air. In the highlands, the high mountains and valleys affect the winds, producing completely independent local circulations. The local winds can spread spores within affected areas and to new areas.

High mountains may prove a barrier to some wind-borne spores, but spores may be carried on people or goods along walking tracks or roads and still reach new areas.

Light. Spores germinate best at night or in dim light. Heavy cloud cover, as in many of the more western parts of the Highlands, and especially in the Southern highlands, may help to make conditions more favourable for the fungus, particularly by decreasing hours of sunlight which in turn would also help to increase the period of leaf wetness.

Planting density, unpruned coffee and heavy shade. In many smallholdings, coffee is often isolated from other holdings, scattered (separated within the holding by other plants), unpruned and grown under heavy shade.

Such coffee may be subject to less rust inoculum due to isolation, and the intervention of shade and other trees. Also, the scattered nature of the bushes may prevent the build-up of mass inoculum such as would occur in closely planted coffee. The higher humidity under heavy

shade may also prevent some leaf fall which is more severe under conditions of low moisture.

On the other hand, these conditions would generate higher humidity (which favours the fungus) and would make spraying more difficult and expensive.

Overall environmental considerations

Generally, the high rainfall, which is also distributed over all or many months of the year in the highlands, offers suitable conditions for near year-round production of spores. However, other natural factors, and the effects of any chemical control which may be carried out, will affect both the rate of spread of the fungus and the severity of the disease at any location.

Chapter 5

Implications for the highlands economy

Introduction

The effect of coffee rust will be different for different groups, and it is useful to distinguish between:

(i) Urban areas;

(ii) Large-scale (and well-managed) plantations;

(iii) Smaller plantations, especially those with lower management levels;

(iv) Smallholder growers in the more accessible parts of the region; and

(v) Smallholder growers who are geographically and economically marginal.

Urban areas

While coffee prices remain high, and before any large-scale effects of coffee rust become apparent, there will be little impact on the urban economies within the highlands and on Lae, the sea port for the highlands and a major supply centre for the region. This is because of the overwhelming effect of current high coffee prices which will more than compensate for any likely fall in production over the next year or two. But should prices return to the long-term trend and the rust have

a severe impact, the implications for these towns are considerable. The smallholder sector, which is likely to be most affected, is a major contributor to production (75 per cent) of coffee, this being the region's single export commodity. Coffee income generates an immediate increase in spending during the harvesting season (Figures 2 and 3) and produces a multiplier effect that is felt throughout the year.

The towns of Mount Hagen and Goroka are the most dependent on coffee income. Any short- or long-term decline in coffee receipts would lower employment and increase social problems in these regions, unless there is a compensating increase in income from other sources.

Large-Scale plantations

Well-managed plantations should be able to continue production at or near the present level provided an appropriate fungicide program is conducted. The program would at first be on an ad hoc basis guided by results in other parts of the world. It would later be adjusted depending on local experience and experimental trials. Current high prices would probably encourage plantations to initiate and maintain adequate chemical control measures.

A program consisting of two applications of a systemic fungicide per year dovetailed with a copper-based fungicide with four applications per year would cost about K120 per hectare for the chemical alone. Additional expenses would be incurred buying and maintaining spraying equipment and paying for labour. Because the extensive drainage systems in plantations would necessitate manual spraying, the Papua New Guinea tree crops survey team (a joint Papua New Guinea, Australian Council for

International Agricultural Research (ACIAR) and Queensland Department of Primary Industries (DPI) project), estimate that this could take total costs to K300 per hectare. These costs can be borne while coffee prices are high, but when prices fall, as is likely, the cost of spraying will considerably erode the profitability of coffee production. This has been the experience in other coffee growing countries (e.g. Brazil) affected by rust outbreaks.

Current plantation costs are estimated by the Department of Primary Industry to be between K940-1400 per hectare. It appears that spraying will inrease the total cost of production in the plantation sector by at least 10 per cent. In addition there may be some yield loss (once trees become infected) which will further decrease profitability. Yield losses may be as low as 5 per cent on plantations under good management, but could be substantially higher where fungicide is not applied effectively.

The tree crops survey also found that about half of the larger plantations process smallholder coffee. Any reduction in processing throughput as a result of lower smallholder output would increase the cost per kilo of processing, and further lower plantation profitability.

The effect on plantation employment is hard to estimate. While there may be some initial increase in employment for spraying, larger growers will seek greater improvements in labour productivity to compensate for lower profitability. Labour productivity in large-scale agriculture in Papua New Guinea has been increasing for some time; any squeeze on profitability will certainly hasten the process.

Smaller plantations

In recent years there has been a growth in smaller plantations of around 20 hectares. These have been encouraged by government policy and funded by loans from the Papua New Guinea Agriculture Bank together with paid assistance from management agencies. Golthorpe (1985:51) suggests that the quality of this management is very patchy, but the tree crops survey team suggest that about two-thirds of such plantations are under reasonable management. Nevertheless, their smaller size, together with high interest and loan repayments means that the cost of rust control will have a greater effect than for larger plantations.

There has been a slight decrease in estate production of coffee over the past nine years. This may be due to low levels of reinvestment, together with declining management skills, but the government believes that the latter has been reversed by the increasing number of plantations hiring management expertise from plantation management companies.

Approval of K15.3 million has been given for over 3500 hectares of intermediate-scale coffee projects through the Papua New Guinea Agriculture Bank since 1979. About two-thirds of estates are now less than 50 hectares.

There are reports that there is already disillusionment among group coffee block owners, but the extent of this is impossible to estimate. Where it exists, it could be a factor in the abandonment of these plantations where debt is high. This would have a considerable impact on lending institutions (especially the Agriculture Bank), who have

found it difficult or impossible to realize traditional land excised and taken as security.

The smaller plantations cover a spectrum from the innovative and dynamic with responsive management, through to those utilizing minimal inputs and with very low yields. It is therefore impossible to predict the impact of coffee rust on this sector as a whole, except to say that already marginal plantations (especially where indebtedness is high) will probably cease production.

Smallholders

Smallholder coffee is spread over about 50,000 hectares in around 400,000 plots owned by some 260,000 families. If all smallholder coffee was severely affected, it would ultimately cease to yield and the smallholder industry would die out. The social, political and economic consequences would be considerable and reach far beyond the highlands. The industry would recover only when resistant varieties became available, when people were prepared to plant them, and then only when the trees reached production several years later.

The spread and severity of the disease. The impact of coffee rust on smallholders is affected by several unpredictable and complex factors, and it is impossible to judge their net effect at this stage. Direct comparisons with coffee growing areas elsewhere in the world is not possible as Papua New Guinea's coffee growing areas are unlike most others. Most of these factors are covered in other parts of this paper, especially Chapter 4, but are summarized here. We must stress again

that the net effects of these influences and others not mentioned here are impossible to predict.

(i) Coffee rust will be more severe at lower altitudes where temperatures are higher. Most smallholder coffee is grown between 1400 and 1800 metres whereas plantations are more concentrated at 1500 to 1700 metres. It is likely that some higher altitude coffee may not be severely affected, but it is impossible to predict the severity at any particular altitude. It is also conceivable that all Arabica coffee at lower altitudes may be very severely affected within a few years.

(ii) Coffee rust will be more severe and infections more difficult to control in western areas where rainfall is higher and occurs throughout the year. Rainfall increases from east to west in the highlands, while seasonality decreases from east to west. Because of high rainfall, coffee rust could be more severe in Papua New Guinea than under similar temperature conditions in other countries.

(iii) Areas with high volumes of passenger and vehicle traffic are likely to have higher rates of spread of the disease, while the opposite would be true of more dispersed and isolated areas. Plantations, with their high levels of staff and vehicle traffic, and their closer trees, could experience rapid spread.

(iv) Smallholder coffee plants which are isolated from other (infected) coffee, and which are scattered among shade trees and other plants, would have higher humidity which may increase the severity of the disease. However, they would experience less windborne inoculum, less build-up of local inoculum and be less susceptible than exposed, heavily bearing plantation coffee in extended plantings.

Overall, the prospects for some smallholders appear bleak, especially those at lower altitudes. While smallholders manage to exist with coffee rust in other countries (such as Kenya), it appears they are able to do so because of a more favourable environment featuring less rainfall and a long dry season, and because less Arabica coffee is grown in areas where the impact of rust would be most severe.

Trends in smallholder production. A very large proportion of smallholder coffee was planted in the 1960s. Given an economic life of about 20 years for smallholder coffee trees, a rapid increase in replanting should have begun within the last few years if smallholder production is to continue at current levels. The Department of Primary Industry claims that replanting has not been occurring at the optimal rate and that there is a danger of a decline in smallholder production in some coffee producing areas.

There is also concern regarding smallholders' management practices; these could be considerably improved and this could generate increased production and incomes.

Recognizing this, the government has funded a Coffee Development Plan, which is to be expanded into the Smallholder Coffee Rehabilitation and Expansion Project (SCREP) in 1987. Thirteen million kina have been tentatively allocated for this project over the period to 1990, but the program is dependent on the Department of Primary Industry, the Coffee Industry Board and the provinces agreeing on an operational plan. A compact variety of a more resistant coffee has been programmed for smallholder replanting in Arabica areas. However, as this variety is very susceptible to leaf rust it is probably no longer an appropriate program to pursue.

Marginal coffee growing areas

There are a number of areas where smallholder Arabica coffee growing is marginal either because prices to the grower are low (because of isolation or poor transport), or where growing conditions are climatically less optimal. Typical areas are those of the 'highlands fringe' where altitudes are lower than in the main highland valleys. They have lower population densities but are more isolated and generally have poorer standards of living than the main coffee growing areas.

Coffee production in some of these areas is already declining and it is possible that, in the absence of improved marketing and extension, reinvestment might not occur when the trees are senile. Since the severity of rust at these lower altitudes is likely to be greater, the economic impact could be very considerable. The population in these areas is already among the most economically disadvantaged of mainland Papua New Guinea.

Should these areas cease production, the impact on the industry as a whole would not be great since their contribution to total production is small. But in the absence of improved alternative economic opportunities the impact on the village economy of some of these already marginal areas could be very considerable.

The marginal nature of existing coffee and the isolation and low population densities would make economic control by the growers or a national or provincial agency more unlikely.

Many people from these areas work on plantations and in urban areas in the highlands. Their future employment prospects would therefore also be affected by any decline in employment in the main coffee growing areas.

The control of coffee leaf rust

Rust control by smallholders. If regular fungicide application is the only control method can smallholders manage their own control? Given the high rainfall in Papua New Guinea coffee areas and the probable need to spray more often than in other countries, prospects look bleak for those areas where effects will be severe. Costs will be considerable, and spraying may be required in the off-season when most villagers have little cash. Spraying will certainly lower returns to owners. Further, spraying equipment (and an ability to maintain it), some knowledge of the chemicals, their mixing and their use will be necessary.

A large part of the answer will depend on the motivation of growers. It is possible that professional village sprayers may emerge

if there is sufficient demand, in the same way that some villagers own coffee pulping machines at present. Village entrepreneurs such as storekeepers or transport operators might add spraying to their business; some kind of group ownership of a sprayer might emerge in some areas. Plantations might assist nearby smallholders; perhaps even at a reduced rate in order to more easily control the disease on their own property, or simply to maintain goodwill.

Village people in Papua New Guinea have shown their adaptability and skill in growing those cash crops which provide the best economic returns. But there is a learning process (as there was with intensive village pig production, which was tried and rejected by villagers), which can sometimes have considerable short-term costs. If village people are able to manage rust control, the costs of the learning process must be minimised so that production losses will be minimized.

Smallholders will only be motivated in this way if they understand why they need to spray, the necessity for the correct timing of applications and the likely impact on their net income. It is possible, however, that this may not occur before there are substantial falls in production.

Some areas may be affected so severely that economic control is not possible. This could be the case at some lower altitudes. Monitoring of such areas is vital in order to judge whether alternative economic activities should be encouraged. This will depend on accurate information on inputs, outputs and costs being provided through sources such as the Papua New Guinea and Australia tree crops study. In any case, a great deal of cooperation and goodwill between the government,

smallholders and others in the private sector involved in coffee (including plantations) will be required.

Effective grower control will also depend on improved agricultural extension and research. The government has recognized for some time that agricultural extension services are weak in most areas and has initiated a number of programs to improve them generally and particularly in the coffee sector. At the same time, the Papua New Guinea Coffee Research Institute has been established with some industry funding. However, these initiatives will not become effective soon enough to assist smallholders or plantations unless they are accelerated.

In more isolated areas where there is poor access to government services and information, smallholder control is less likely in the short term.

Control of rust. Given the necessity of spraying against coffee rust, implementation delays will have an impact on smallholders and poorly-managed plantations. There is therefore a need for a control program, with considerable government input, to act as a holding operation to assist with long-term control, and to monitor rust control research.

Although appreciating the immediate and continuing chemical controls being undertaken by the Department of Primary Industry, we believe that with present resources and organization, the possibilities of mounting an effective fungicidal control campaign of the magnitude required are minimal. Village coffee growers do not, in general, have

the necessary skills, knowledge or equipment to apply fungicide at suitable intervals and there is little capacity within the extension system to impart these skills and knowledge to them.

The ability of government to conduct such a campaign is limited by:

(i) Lack of managerial skills within Papua New Guinea to operate on the massive scale needed (50,000 hectares of smallholder coffee);

(ii) Unavailability of skilled staff for supervision, machinery maintenance and other tasks;

(iii) Supply and transport constraints on obtaining sufficient fungicide, machinery and transport on the scale required; and

(iv) Poor road access to, and scattered nature of most smallholder plantings.

If this assessment is correct, reliance on existing institutions, even with expanded budgetary support, will fail and losses to smallholders will be considerable.

Impact on the highlands village economy

In the absence of effective control, coffee rust will result in major losses in cash income and employment for highland villagers both in main valleys and on the highlands fringe. Some implications of this are:

(i) Reduced cash income will reduce villagers' capacity to purchase consumer goods such as tools, clothing, saucepans, radios and kerosene.

(ii) A significant proportion of cash income appears to be spent on high quality food (such as rice, tinned fish and animal fat) that is deficient in traditional diets. The lack of such foods will decrease village nutrition, especially for children under five and pregnant and lactating women.

(iii) Reduced cash income from coffee production will make villagers more vulnerable to partial or complete failure of their subsistence food supplies and increase the probability of nutritional stress.

(iv) Any loss of cash income will place greater pressure on land and labour for village food production, although some coffee labour will be available for growing food. Although population densities and food production technologies are such that people should be able to cope, in some densely populated locations, more intensive land use is likely to result in environmental degradation such as soil erosion and conversion of forest into grasslands.

(v) The loss of large numbers of jobs because of a downturn in the regional economy would have serious implications for law and order. This includes tribal fighting and crimes against people and property in both urban and rural areas. The sharp increase in crime in 1982 and 1983 was associated with the

decline in employment in all sectors of the economy caused by the economic depression. Increased tribal fighting and crime is likely to occur in the highlands if large numbers of men become unemployed and employment prospects for young men are reduced. Such a deterioration of law and order is also likely in Lae, Port Moresby and other coastal towns.

Political implications

A national election is scheduled for June 1987, just after the start of the 1987 coffee harvesting season. If the spread of coffee rust is rapid, production effects could begin to occur at about that time, although the main effect would likely to be felt during the 1987 coffee harvesting season and thereafter. The present government has a broad political base in the highlands, and its response to the rust problem as perceived by the electorate, may have a significant impact on the outcome.

Monitoring of the coffee industry

One of the difficulties in assessing the impact of coffee leaf rust in Papua New Guinea is the lack of detailed information on the industry. The Agro-Economic Survey for Coffee, Cocoa and Copra has already begun and is jointly funded by the government, the industry boards and ACIAR. A survey of plantation coffee has been computed and a survey of smallholder coffee has just been commenced. It may be worth reviewing the timing of the survey and its analysis to quickly provide information on the smallholder sector.

Ongoing monitoring of the industry will be necessary to assess the impact of rust and the effectiveness of control measures implemented by growers or the government. It will also assist longer-term development of the industry and provide some feedback for research programs on rust control and resistant varieties. (This would be in addition to the detailed research monitoring and crop loss assessments being carried out by pathologists.) It will also provide some indications of the efficacy of agricultural extension and the associated spread of improved cultivation and rust control.

It will also be important to monitor areas likely to be marginal for coffee after infection by coffee rust. For some of these areas, it may be wise to discourage coffee in favour of other activities. Research into economic alternatives may be necessary.

Chapter 6

Implications for the national economy

Introduction

The effect of coffee rust on the Papua New Guinea economy will depend on how quickly it spreads and the severity of the disease in various areas. We have already listed those natural phenomena (such as temperature, rainfall, seasonality and growing conditions) which will have an impact on the spread and severity of the disease, and have concluded that the net effect of these is unpredictable within the relatively unusual coffee growing conditions of Papua New Guinea. Apart from the environmental factors, the impact of rust on coffee production will further depend on growers and government mounting an effective control program.

For each grower, response to the disease will depend on the additional costs (monetary or non-monetary) caused by the disease in relation to gross returns. Gross returns will in turn be heavily dependent on international prices; production (especially by smallholders) tends to be relatively higher at times of higher prices in Papua New Guinea.

This chapter discusses the short-term impact of current high coffee prices coupled with the long-term impact of coffee rust. Three possible outcomes are presented.

The impact of current high coffee prices

At the time of writing, coffee prices were unusually high (approximately K4000 per tonne) as a result of the drought in Brazil. Thus, any production effect of coffee rust will be vastly outweighed in the short term by the effect of current prices. Current indications are that the long-term effects of the drought on Brazilian production are slight and that the price will return to around K2000 per tonne within a year or two.

Papua New Guinea's growth in gross domestic product (GDP) has not kept pace with population growth in recent years and real GDP per head has declined. Much of the increase in national income has come from minerals while agricultural export income has remained static. The Papua New Guinea government has recognized that without a substantial increase in agricultural incomes, income distribution will suffer and income per head will fall. It has therefore announced a number of programs to increase government and private investment in agriculture with emphasis on smallholders. These initiatives are still in the planning stages and will have little immediate impact. If coffee rust has a serious impact, it will be in an already difficult economic situation, especially for rural areas.

Another effect of high coffee prices is that International Coffee Organisation quotas have been suspended. Papua New Guinea can therefore sell last year's stocks at this year's prices. Further, the government had assumed in the 1986 budget that it would be necessary to stockpile coffee (and reduce exports) in 1987 for bi-annual International Coffee

Organization stock verification. Since quotas have now been suspended, it is probable that 1987 exports will be much higher than expected.

Even if we take the worst view of the spread and severity of coffee rust, its impact on the national economy will not become apparent until mid or late 1987. Given the seasonally low production of coffee between October-November and March the impact could be even further delayed until the 1988 season. If only at that time was the national and regional impact of coffee rust found to be serious, it would be a situation from which it would be difficult and costly to recover.

The 1986 budget estimates

In order to estimate the possible impact of coffee rust, it is worth setting out the government's estimates from the 1986 budget (see Table 8) and the assumptions upon which they were based.

Table 8 Forecast coffee prices and production, 1986-90, 1986 budget (constant 1986 kina)

Year	1986	1987	1988	1989	1990
Coffee price (K/tonne)	2,373	2,632	2,094	2,214	2,174
Coffee exports (tonnes)	51,000	37,000	63,000	55,000	58,000
Export revenue (K million)	121.0	97.4	131.9	121.8	126.1

Source: Department of Finance and Planning estimates.

These estimates were based on the following assumptions:

(i) Real prices would vary between K2000 and K2600 per tonne over the period.

(ii) International Coffee Organization quotas would necessitate stockpiling in 1987 because of the International Coffee Organization's stock verification exercise. These stocks would be exported in 1988, accounting for the low value of exports in 1987 and higher than average 1988.

(iii) Increased production from 20 hectare coffee plantation expansion would begin from 1985.

High prices and coffee rust disease have now rendered these estimates invalid.

Estimates of the production impact of coffee rust

Earlier chapters discussed factors influencing the spread and severity of coffee rust and its impact on coffee production. Based on this analysis, we now estimate possible coffee production outcomes. Our conclusions are speculative but our objective is to place some bounds on the possible outcomes. These estimates assume that one-third of plantations have low levels of management (preliminary estimates of the tree crops survey team).

These possible outcomes deal only with the period to 1990. Outcomes after 1990 will depend on control measures as well as the testing, propagation and use of rust resistant varieties.

(i) Worst outcome Coffee production will decline by 71 per cent to 14,600 tonnes in 1990.

This is based on the following assumptions:

(a) Smallholder rust control measures are ineffective or not instituted.

(b) Coffee at all altitudes will be seriously affected by rust, to the extent that without spraying, production will decline to such an extent that it will no longer be economically viable to continue picking.

(c) As a result of (a) and (b) all smallholders will cease production.

(d) Production on poorly managed plantations will decline by 50 per cent.

(e) Production on well-managed plantations will decline by 10 per cent.

(f) There will be some net production increases from new coffee plantations, and the level of management of existing poorly managed plantations will improve.

(g) Robusta production will be virtually unaffected as rust infections are not expected to be severe.

(ii) Intermediate outcome Coffee production will decline by 28 per cent to 36,200 tonnes in 1990.

This is based on the following assumptions:

(a) Some smallholder coffee at higher altitudes will not be seriously affected by rust and at lower altitudes control

measures will be only partially effective. Smallholder production will be reduced by 50 per cent.

(b) Production on poorly managed plantations will be reduced by 30 per cent, but the proportion of poorly managed plantations will decline with general improvements in management skills and experience.

(c) Production on well-managed plantations will be reduced by 5 per cent.

(d) Robusta production will be virtually unaffected.

(iii) Best outcome Coffee production will not decrease from the current level of 50,000 tonnes, but will be 8000 tonnes less than current official projections.

This is based on the following assumptions:

(a) The worst effects of rust will be mostly confined to below 1400 metres, where 6000 tonnes of smallholder and plantation coffee will be lost.

(b) Control measures will be effective for coffee above 1400 metres.

(c) Robusta production will be virtually unaffected.

To evaluate the impact of these possible outcomes on production, a small linear model was used. The model assumes that two-thirds of estate coffee comes from well-managed plantations and the remaining third from poorly managed plantations. It also assumes that (partly

because of the rust problem) an increasing proportion of plantations become better managed. Finally, it assumes that the small Robusta industry continues virtually unaffected by the rust problem.

Possible effects on production and export receipts

Table 9 sets out likely trends in production based on the assumptions set out in the previous section, and compares them with the estimates made in the 1986 budget. Price trends for the best outcome assume that prices will remain high in 1987, while the middle outcome assumes they will fall significantly in that year and the worst outcome assumes a price return to the long-term trend in 1987. For the period 1988-90 there is no reason to change the price assumptions of the 1986 budget.

The low level of chemical applications to coffee in Papua New Guinea has enhanced the marketing of coffee to countries with pure foods legislation. The introduction of spraying may therefore result in lower prices in these markets and decreased export receipts.

Balance of payments

The reductions in anticipated export receipts from coffee after 1987 will inevitably have repercussions on the balance of payments. However, there would be an offset against the balance of trade since imports would be reduced as a result of the lower level of domestic demand. However, imports of large quantities of fungicides and equipment will be necessary to spray the coffee crop.

Table 9 Coffee production and export receipts under three possible outcomes in comparison with 1986 budget estimates, 1986-90 (Constant 1986 kina)

Year	1986	1987	1988	1989	1990
1986 budget:					
Coffee price (K/tonne)	2,373	2,632	2,094	2,214	2,174
Coffee exports (tonnes)	51,000	37,000	63,000	55,000	58,000
Export revenue (K mill)	121.0	97.4	131.9	121.8	126.1
Best outcome					
Production (tonnes)	50,000	50,200	50,200	50,094	49,825
Price (K/tonne)	4,000	3,500	2,094	2,214	2,174
Export revenue (K mill)	197.9	173.8	104.0	109.7	107.2
Difference from budget	+76.9	+76.4	-27.9	-12.1	-18.9
Intermediate outcome					
Production (tonnes)	50,000	48,096	45,920	41,190	36,200
Price (K/tonne)	4,000	3,000	2,094	2,214	2,174
Export revenue (K mill)	197.9	142.7	95.1	90.0	77.6
Difference from budget	+76.9	+45.3	-36.8	-31.8	-48.5
Worst outcome					
Production (tonnes)	50,000	44,192	35,946	26,537	14,672
Price (K/tonne)	4,000	2,632	2,094	2,214	2,174
Export revenue (K mill)	197.9	114.9	74.2	57.6	30.8
Difference from budget	+76.9	+17.5	-57.7	-64.2	-95.3

Source: Authors' estimates.

Table 10 only attempts to measure the effects of the three outcomes on foreign exchange reserves as measured against the 1986 budget (which assumes no coffee rust).

Table 10 Change in foreign exchange reserves under the three scenarios, 1986-90 (K million, constant 1986 prices)

	1985	1986	1987	1988	1989	1990
Foreign exchange reserves (budget)	424.0	436.0	391.5	480.5	514.7	439.6
Best out come						
Est. reserves	424.0	466.8	452.9	530.8	560.2	477.5
Intermediate outcome						
Est. reserves	424.0	466.8	440.4	514.7	536.2	441.7
Worst outcome						
Est. reserves	424.0	466.8	429.3	495.2	503.7	390.5

Note: These estimates assume a marginal propensity to import of 0.6, which is perhaps high for the country as a whole, but reflects the high import content of highlands village expenditure patterns. If the marginal propensity to import is less than assumed here, the impact on the balance of payments would be worse than estimated above.

These estimates suggest that the effects of coffee rust are not likely to be very dramatic on Papua New Guinea's balance of payments position. Even under the worst outcome the anticipated import cover is only reduced by slightly over half a month by the end of the period. Under all three outcomes the balance of payments remains healthy by 1990.

However, the government's estimates of foreign exchange reserves are forecasts which are dependent upon high levels of new investment occurring in the mineral sector. The situation will be worse than portrayed by these figures if that investment does not go ahead as projected. On the other hand, decreasing oil prices will have had a beneficial impact on the trade balance.

National income and growth

Private consumption by coffee producers will be affected in the latter three years under all three outcomes. This will have multiplier effects substantially larger than the initial reduction in coffee producers' income and consumption. However, the fluctuations in incomes to growers (and hence on the economy generally) could be substantially reduced if the coffee stabilization fund is operated effectively.

It is likely that national income will be boosted in 1986 and possibly 1987 (if coffee prices remain at high levels) but that growth will be reduced in the later part of the period. The government is already projecting high growth in 1986 and 1987 as a result of Ok Tedi coming into full production - but is forecasting lower growth thereafter. The effect of the three outcomes will further accentuate higher growth in the earlier part of the period and lower growth in the later part.

Government revenue and expenditure

As indicated in Chapter 2, the coffee industry is an important contributor to the national economy. Estimates in that chapter indicated that the industry contributes at least 10 per cent to total internally-generated revenue.

Any marked decrease in coffee income affects government revenue through reductions in income taxes, export taxes, excise taxes and import levies on the induced reduction in imports. Because of these multiple effects, the greatest impact of any decline in coffee income appears to be not on the balance of payments, but on government revenue. This effect

could be compounded by any increase in government spending necessitated by coffee rust control and research.

But the high coffee prices of 1986 (and probably 1987) will generate more internal revenue than anticipated by the 1986 budget. Overall revenues for the whole period may therefore not be greatly reduced. However, 1986 and 1987 are pre-election years and it is unlikely that these windfall revenues would be carried over to later years.

Only under outcome three would the overall impact on government revenue for the five-year period be serious; while there would be considerable price effects in 1986 and 1987 giving increased revenues, this would be more than outweighed by the production effects from 1988 onward.

Therefore, the most serious repercussions of the spread of coffee rust in a macroeconomic sense could be in its impact on the budget rather than the balance of trade and payments.

If considerable increases in government expenditure are necessary as a result of severe rust, the implications for the government's finances are serious in 1988 and after. The government's financial involvement would, however, be reduced if the coffee industry funded as much as possible of the necessary expenditure. Current high coffee prices coupled with the expectation that production will only be minimally affected in the current coffee year, means that coffee growers' incomes will be high in 1986. It would be appropriate to apply some of these funds to assisting the future growth of the industry. This is taken up in more detail later in this chapter.

Rust control costs

It appears that protectant fungicides will have to be applied immediately and at regular intervals both before, during and after the wet season to areas affected or immediately threatened by rust. Apart from the logistics of applying fungicides regularly on a large area of the crop, there is the important problem of cost.

Two types of fungicides could be applied. These are protectants (such as copper-based fungicides) and systemics.

Using the Kenya experience as a guide, two applications of a systemic fungicide at two litres per hectare dovetailed with four applications of a copper-based fungicide at four kilograms per hectare may be required for a region with rainfall patterns as in Papua New Guinea. If the systemic fungicide cost were K25 per litre and the copper fungicide K2.4 per kilogram, and if the entire coffee area had to be sprayed, the cost for these chemicals alone would be K6,160,000.

However the above regime using both types of fungicide may need to be amended; the number of applications and the concentrations per hectare may both need to be increased or decreased as determined by experimental trials and field performance. Also, other fungicides may be cheaper or the above systemic may cost less if bulk shipments can be arranged. Further, some holdings, especially isolated coffee blocks, may escape infection for some time and in any case it may not be possible to spray infected isolated smallholdings. All these adjustments would alter the estimated cost per year for fungicides.

As well as the cost of chemicals, there would be the costs of spray packs, protective clothing, maintenance of equipment, transport, labour, housing, extension services, supervision and management. These would increase the total costs substantially each year.

The organization which would be required to put such a program into operation would be enormous, even if handled by a national rust control body. Keeping track of blocks sprayed, fungicides and concentrations used and dates of spraying would be a formidable task.

Employment

Lower coffee production will inevitably reduce formal employment opportunities throughout the highlands economy in a multiplicative fashion. Labour productivity on plantations has been increasing in recent years and the trend is continuing. Any increase in plantation costs will probably encourage growers to seek further improvements in labour productivity rather than engage additional labour. Spraying teams may be required by the Coffee Industry Board and the Department of Primary Industry, but the employment generated by this would be small in relation to current employment in the industry.

Most important will be the effects on the self-employed smallholder who may lose part (or all) of his or her source of income. There are approximately 226,000 households who are involved in coffee growing and earn income from this source. Many of these households do not have alternative income earning opportunities and they are now firmly locked into the cash economy. The extent and severity of the problem will determine how much this type of employment is affected.

Law and order

If the impact of rust on employment and smallholder incomes is significant, increased rural/urban migration and increased rural unemployment would be likely in coffee growing areas. Highlanders with little other income earning opportunities available to them will increasingly look to the towns for employment.

Papua New Guineans have tended to migrate to those areas of the country with higher rural incomes such as the Western Highlands. Economic factors have dominated migration patterns and are likely to continue to do so. The 1977 Urban Household Survey provided clear evidence that the majority of migrants are men who are either taking up or looking for work.

Lae (and to a much lesser extent, Port Moresby) would also feel the effects of unemployment and increased crime in the absence of employment generated by other source.

Stabilization funds and a rust levy

A rust levy. For many smallholder coffee growers, coffee is a crop which involves very little (if any) cash input. Therefore, growers are unlikely to see the need to spend money spraying their coffee crops. However, the Coffee Industry Board could very effectively assist the industry (and particularly the smallholder sector) if it imposed a levy on coffee producers which could be used to finance an education and chemical control program.

In a similar situation in Nicaragua, an immediate US 5 cents per pound. levy was placed upon all coffee exports to help finance a control

program. In Papua New Guinea terms this translates into about 10 toea per kilogram. On an estimated crop of 50,000 tonnes this would yield K5 million, a substantial contribution towards financing the cost of a spraying program. It would only reduce coffee income from K200 to K195 million in the current year - which would still be a considerable increase in earnings. The introduction of such a levy would reduce the financial strain upon the government.

Thus, there appears to be little reason why the industry could not fund a spraying program. In future years when production is more severely affected and prices are lower, the government may have to assume more responsibility for purchase of fungicides and organization of the program.

The Coffee Stabilization Fund. The Coffee Industry Board should also be collecting levies to fund the inevitable shortfalls in income that will occur. The large size of the fund has made administrators reluctant to build it up further during the current period of high prices. However, now that rust has occurred, it would be an opportune time to increase contributions to the fund. These would then become a useful source of income in the future.

Both of these courses of action - collecting a 'rust levy' and maintaining income stabilization - would need to be initiated almost immediately if they are to be successful. The 1986 coffee season is currently under way and some of the possible accumulations have already been lost. With uncertain production and price levels beyond 1987 it would make sense to use high incomes in 1986 as a means of financing both an extensive spraying program and assured future income.

Possible assistance in the event of a major problem

Should there be a major devastation of the coffee crop, there are several possible sources of external assistance available to Papua New Guinea.

The potentially most important is the STABEX scheme, a mechanism under the Lome III Convention between the European Community (EC) and the African Caribbean and Pacific (ACP) states for the stabilization of export earnings. This scheme has been operating since the first Lome Convention and was set up to cover losses of earnings caused by a drop in prices or production of the main ACP agricultural exports. Papua New Guinea has already had access to STABEX funds (in 1981 and 1982) as a result of lower export revenues from several of its major crops.

Right of access to STABEX funds is automatic under certain conditions. The commodity in question must comprise more than 1.5 per cent of Papua New Guinea's export receipts (coffee does), and the fluctuation in the value of Papua New Guinea's coffee exports to EC countries should be greater than 1.5 per cent from the reference level (the average of the past four years). Papua New Guinea would be able to obtain STABEX funds in the event of coffee rust having a major impact on export receipts.

A second possible source of assistance is the International Monetary Fund's (IMF) Compensatory Financing Facility. Papua New Guinea has used this facility also on a previous occasion. The IMF will lend money from this facility to a country: if it has a balance of payments problem; if the balance of payments problem is temporary and beyond the control of the

member; and if the IMF is convinced that the country to which it is lending will cooperate with it in its policy recommendations. Papua New Guinea could obtain up to K60 million as a low interest short-term loan under this scheme if it qualified for assistance.

Both the World Bank and the Asian Development Bank also lend money for agricultural projects. If the government of Papua New Guinea proposed a Coffee Rehabilitation Project or a Coffee Sector Project, it is likely that one of these two organizations would provide financial assistance. At present the World Bank is reluctant to fund coffee projects because of the possible impact on future world prices.

The United Nations Development Program (UNDP), the Food and Agricultural Organization and the Commonwealth Secretariat could also assist Papua New Guinea in the event of a coffee crop disaster. However, their funds are limited and aid is likely to be in the form of technical assistance programs rather than the provision of finance.

Summary

Outcome three looks particularly problematic for Papua New Guinea within the next five years. The other two outcomes would not create particular problems for the macro economy - except for the timing of government revenue and expenditure. The major impacts would be upon the village and highland regional economy. Many people could be left without alternative incomes.

The major short-term macroeconomic effect appears to be on government revenues and expenditure. As the budget will be squeezed by whatever

eventuates in the coffee industry, it would be most practical if the industry bore as much of the cost of coping with the problem as possible.

Chapter 7

What needs to be done

This chapter briefly outlines the action we believe to be necesary to reduce the impact of coffee rust on affected growers, the highlands economy and the national economy. Indications are given of how feasible such action is likely to be.

We do not presume to suggest to the Papua New Guinea government and coffee industry how best to organize any intervention as this is best decided within Papua New Guinea.

Measures to inhibit spread of the disease

It is vital that the spread of coffee rust disease be prevented as much as possible to reduce its impact and to provide time for the determination of the most appropriate fungicide regimes and for longer-term measures such as the evaluation of resistant varieties under local conditions. Any program to inhibit the spread of the disease should include:

(a) Quarantining affected plants and the harvested crop of affected plants; prevention of movement of coffee plants and plant parts, apart from processed beans.

(b) A fungicide spray program of infected plants.

(c) A fungicide spray program of unaffected plants in critical locations, such as those adjacent to affected coffee and adjacent to the Highlands Highway.

(d) Publicity to growers and the general public on the importance of these measures and the serious impact rust may have if uncontrolled.

These measures will require a considerable input from government and the coffee industry. We understand that these measures have already commenced; it is crucial that they are continued and that progress is monitored.

Measures to control rust on affected plants

If a large proportion of coffee plantings becomes affected, control measures will be necessary if the industry is to survive. In the medium term (5 to 10 years), and possibly for a longer period, control measures will probably be fungicidal spraying of infected coffee plants at appropriate intervals. This can be done (at some expense) on well-managed plantations. Most smallholders would not be able to conduct an effective spraying program themselves and there are no existing structures within Papua New Guinea capable of doing it for them on the required scale. It may be possible to upgrade existing organizations or to create new ones so that most smallholder coffee can be protected by regular fungicide application. The task would be daunting for the following reasons:

(i) There are about 216,000 smallholder coffee-growing households in the highlands with an average of about 1.5 coffee plots per household.

(ii) Road access to many coffee plots is poor or non-existent.

(iii) The quantities of chemical needed are vast. For example 200 tonnes of copper-based fungicide may need to be applied to smallholder coffee every month during the wetter months. At most locations in the highlands there are 10 to 12 months per year which receive a mean monthly rainfall of more than 100 millimetres (Figure 6).

(iv) Organization on a massive scale and a commitment to appropriate timely spraying would be required. Such an organization does not exist within Papua New Guinea.

We have suggested that some smallholder control may be possible, and that there may be some private sector response that will provide spraying in some areas. Initially, this is only likely in the more accessible and higher income areas. Even so, any smallholder response is totally dependent on good extension services and information dissemination. Unfortunately, as pointed out in a recent survey (McKillop, Williamson and Associates 1982), agricultural extension capacity is low and organization poor.

It is crucial that some organization recommend, establish and coordinate rust control measures where appropriate. It must disseminate sufficient information for all types of growers to know what the implications of rust are, and what their actions should be.

The ultimate severity of the disease in Papua New Guinea is difficult to predict, although some areas (especially at low altitudes) will undoubtedly be severely affected. It is not sufficient to 'wait and see' what the outcome will be, since if it is severe, valuable time will have been lost.

Research within Papua New Guinea

There is only limited capacity to conduct research on coffee in Papua New Guinea, although a research structure has recently been created and three professional research staff are employed at the Coffee Research Institute at Aiyura. This is partially funded through a research levy on coffee. This is in addition to the Plant Pathology Branch of the Department of Primary Industry.

A considerable expansion of research capacity is required to reduce the impact of coffee rust. This should focus on the chemical control of rust, rust resistant varieties and ongoing field monitoring of the economic and biological impact of the disease.

Chemical control of rust. There are numerous technical questions on types of application, appropriate chemicals, volume per hectare, frequency of application and the economics of chemical control. Since these factors are likely to depend on rainfall, seasonality and temperature (altitude), any research program would have to be replicated at several sites. The answers to these technical and economic questions cannot be provided by the extensive literature on chemical control of coffee rust in other countries, although such information is a necessary

foundation. It must be conducted within the Papua New Guinea coffee growing zones.

Resistant varieties. The use of resistant coffee varieties is a possible long-term solution, particularly for the smallholder sector, although it is not a guaranteed solution because of the capacity of the rust organism to mutate and overcome resistance. Some resistant material is already available in Papua New Guinea and other material can be imported from other coffee research countries and from Australia, perhaps with build-up in Australia as well as in Papua New Guinea. These would then all need to be evaluated in Papua New Guinea for yield, liquor quality and other agronomic characteristics under local conditions.

The importation into Australia of hybrid seed or lines from already rust-infected countries should, in our opinion, be made only through an intermediate quarantine station in a non-coffee rust country such as the United States of America (at Beltsville near Washington, D.C.) or England (at the Royal Botanic Gardens, Kew). At such an intermediate quarantine station, the seed should be redusted and repacked. Post-entry quarantine in Australia should be for the detection of other diseases.

Once resistant varieties have been adequately evaluated, propagation of planting material on an adequate scale will require time and substantial efforts (smallholder production presently comes from over 100 million individual coffee trees).

Australia may be able to assist with rapid multiplication of suitable planting material once this is available, or with development of suitable technologies (such as tissue culture) for rapid multiplication.

We believe that it is possible for Papua New Guinea to develop an adequate research capacity for the provision of technical solutions to counter coffee rust, although some assistance may be required from outside.

Monitoring of disease impact. It is crucial to establish an ongoing monitoring program to assess the impact of the disease, and the effectiveness of control measures. To a large extent this should be part of research on chemical control. In addition, it is important to assess the economic impact on growers, both large and small. The tree crops survey is about to move into the smallholder phase and should be producing valuable information on the economics of smallholder production. This could be used as a basis for planning control. The survey may need to be altered slightly to take greater account of possible rust impact.

Alternative cash crops

It is likely that alternative cash crops will be needed for villagers whose coffee is seriously affected by rust, particularly at lower highland altitudes (below 1400 metres). Possibilities for alternative cash crops include:

(a) Cardamom. This is proving to be a very successful cash crop at altitudes from 600 to 1600 metres. It is a particularly attractive alternative to coffee where road links do not exist.

(b) Robusta coffee. This can be grown up to about 1700 metres in Papua New Guinea, although commercial production is presently from sea level to about 550 metres. It is less attractive to growers than Arabica coffee because of a somewhat lower price per kilogram and lower yields. However because of its greater resistance to coffee rust, it may be an attractive alternative.

(c) Citrus. There is a market for mandarins and oranges within Papua New Guinea which is only partially satisfied by domestic production. The domestic market is small, but for lower altitude locations with road access to urban markets (such as the Baiyer Valley), citrus production may be an attractive alternative to Arabica coffee.

It is important to identify those areas where Arabica coffee should be discouraged because of rust, and alternative crops or activities identified.

Strengthening quarantine in Papua New Guinea

Coffee rust could have arrived in Papua New Guinea, on a person, on his or her clothes, an illegal import of some part of a coffee plant, or as airborne spores. Although it is now too late to prevent the disease

from entering Papua New Guinea, it is not too late to prevent other races of coffee rust and other important plant diseases from being introduced.

Papua New Guinea has already strengthened its quarantine procedures. Further public education campaigns on the need to respect quarantine regulations are also part of an ongoing program. Such a program should be directed especially at people involved in all aspects of agriculture. This group is more likely to either deliberately break the quarantine barrier or accidentally transport spores into Papua New Guinea than other groups.

The macroeconomic effects

We have already suggested that the greatest economic impact at the national level will be on government revenue, although the balance of trade will also be affected. The net budgetary effect on the government depends on what expenditure is necessary in the long term.

Since the government will be getting windfall revenues in 1986 and 1987 from coffee, but lower than budgetted revenues in subsequent years, it is important that relevant government agencies plan to spend more money on the coffee industry in those later years. Because of the squeeze on the budget in a period of fiscal restraint, it would be appropriate for the industry to bear much of the cost of a control program. This will be possible in 1986. However, the industry's ability to contribute from 1987 onwards may be seriously impaired.

Improvements in smallholder management

An adequate smallholder response to coffee rust depends on improvements in management and understanding of coffee. The government has been aware of the vast potential for increasing rural incomes through smallholder management improvement, and a Coffee Development Plan is being formulated to encompass a Smallholder Coffee Rehabilitation and Expansion Program (SCREP).

Improving smallholder management is essential and would go a considerable way to assisting the control of rust, although it would not be effective alone.

It is therefore important that the details of SCREP be finalized as soon as possible for funding and implementation in 1987 as planned. It may be necessary to amend the program to take account of rust.

Where Australia could help

We are not in a position to propose means by which Australia could assist Papua New Guinea in reducing the impact of coffee rust. This would be better evaluated from within Papua New Guinea. However we recommend that the Australian government should meet any reasonable request for assistance from the Papua New Guinea government. Some examples of the types of assistance which we consider appropriate for support include:

(a) Assistance with immediate problems, such as obtaining supplies of protective clothing suitable for tropical conditions,

equipment and fungicides and their rapid transport to Papua New Guinea;

(b) Rapid multiplication of coffee lines from overseas, in Australia after repacking and redusting of seed at an intermediate quarantine station; and

(c) Recruitment of resident staff for disease control and research where needs are identified by Papua New Guinea.

Appendix 1

Quantity, value and per cent of total exports of tree crop exports from Papua New Guinea
(volume in '000 tonnes, value in K million)

	1978	1979	1980	1981	1982	1983	1984
Coffee							
Volume	45.8	49.6	51.0	47.1	41.1	52.5	49.4
Value	107.2	125.0	118.7	74.2	77.8	94.7	110.7
Per cent	19.0	16.6	17.2	13.1	13.6	13.8	13.4
Coco							
Volume	27.1	27.1	28.7	27.8	28.7	26.3	34.1
Value	63.0	60.9	46.4	34.1	31.8	41.4	67.0
Per cent	11.2	8.1	6.7	6.0	5.6	6.0	8.1
Copra and copra products							
Volume	136.9	140.1	143.3	145.8	123.4	132.9	134.2
Value	36.5	60.7	42.7	32.5	25.7	45.5	88.5
Per cent	6.5	8.0	6.2	5.7	4.5	6.6	10.7
Palm and palm kernel							
Volume	32.6	38.2	38.3	46.9	90.3	87.0	129.9
Value	11.2	15.4	12.8	14.6	23.6	25.1	75.7
Per cent	2.0	2.0	1.9	2.6	4.1	3.7	9.2
Tea							
Volume	7.0	7.0	7.9	7.0	6.9	7.2	7.3
Value	7.8	8.0	8.5	7.1	6.7	10.4	17.1
Per cent	1.4	1.1	1.2	1.3	1.2	1.5	2.1
Rubber							
Volume	4.1	4.0	4.0	4.5	2.3	2.7	3.4
Value	2.6	3.5	3.7	3.4	1.4	2.2	2.4
Per cent	.5	.5	.5	.6	.2	.3	.3
Total exports	563.8	754.4	691.8	566.0	570.4	687.4	823.7

Source: Bank of Papua New Guinea, various issues, Quarterly Economic Bulletin.

Appendix 2

The International Coffee Organization

The history of the agreement

Declining world prices for coffee in the mid 1950s created a situation which required international action. After some attempts by consuming countries to regulate the market on their own, an International Coffee Agreement (ICA) was signed by a large group of producing and consuming countries in 1962, and came into force in October 1963. The agreement sought to regulate the market by a system of quotas on producing countries. The agreement succeeded in halting the decline in prices, although coffee prices remained stagnant in real terms throughout the 1960s.

The agreement was renewed in 1968. With strong market prospects in the early 1970s, producing countries pushed for higher prices and lower overall quotas than consuming countries were willing to accept. Producers and consumers were not able to reach agreement and no regulation of the coffee market under the ICA was in force after 1973. Consequently, the 1968 agreement was extended, without its economic provisions until 1976.

Under the 1976 agreement, quotas for each country were determined not only on the basis of past export performance but also on the basis of the stocks held by each of them.

The member producing countries of the agreement account for over 99 per cent of world net exports of coffee and importing member countries account for about 90 per cent of world net imports.

The quota system works on a quota allocation to each country based on historical performance as well as stocks held by member countries. Stock verification exercises are held by the International Coffee Organization (ICO) every two years. Hence, Papua New Guinea has undertaken two stock piling exercises over the past four years. This has been done in an attempt to increase its quota allocation under the ICA. Normally, sales of non-quota coffee are made to non-member countries of the ICO but at substantially lower prices.

In the early part of the 1980s coffee was being sold to non-member countries of the ICO at prices which were (as low as) half the member ICO price. The coffee stabilization fund was used on these occasions to top up the non-member coffee sale price to help boost producers' incomes.

The quota system attempted to keep the coffee price within a certain specified range. When international prices fell below the range, quota allocations were progressively reduced (as occurred in 1984) in an attempt to limit supply and bring the price back within the ICO's range. When prices went above the predetermined range, quota allocations were increased - and ultimately abandoned if prices continued to rise. This occurred in February 1986 as a result of the drought in Brazil.

Papua New Guinea and the International Coffee Organization

Papua and New Guinea became members of the ICA along with Australia from its commencement in 1963. Because of the colonial relationship at the time, Papua New Guinea was classed with Australia under the agreement. No export quota was required for Papua New Guinea prior to independence as long as the combination of Australia and Papua New Guinea remained a net importer of coffee. Hence, as long as this situation continued, Papua New Guinea's coffee was freely marketable.

This situation changed after independence, when Australia was classified as a consuming nation under the agreement and Papua New Guinea was reclassified separately as a producing nation.

However, the 1975 frost in Brazil moved prices upwards in 1976 and 1977. As a result quotas were not enforced in the second half of the 1970s.

This situation changed with the deterioration in coffee prices in the late 1970s and early 1980s and led to the reintroduction of export quotas in September 1981. The price range of the agreement was set at US115 cents per pound and US155 cents per pound. The agreement helped to stabilize prices over the early part of the decade when most other commodity prices were declining rapidly.

However, the establishment of the quota system led to the development of a dual market system in the coffee industry. Papua New Guinea had an export quota under the ICA of around 35,000 tonnes in 1981 (the first full year of quotas) and was obliged to sell all its

additional production of 12,640 tonnes to non-member countries at discounted prices.

At this time, the Coffee Industry Board made a decision to use the fund to subsidize the prices of non-member sales rather than purchase this additional coffee and store it. This policy was continued up until 1984.

In 1984, the Minister for Primary Industry decided that no coffee would be sold to non-member countries in the 1985 coffee season and that it would all be stockpiled for the 1986 stock verification exercise. This was done in an attempt to increase Papua New Guinea's quota for the ensuing two years.

This stockpiling exercise was carried out by the exporters with the fund financing the storage costs of the coffee and the interest foregone on monies tied up in coffee stocks.

However, events overtook the stockpiling exercise.

Recent developments in the international coffee market

Quotas and the price support range for the 1986 coffee year were announced in early October 1985. The global export quota was set at 58 million bags and the price support range was set at US 120-140 cents per pound.

Under the terms of the arrangement only two adjustments to the quota were allowed in each quarter. Intervention in the form of one million and one and a half million bag quota cuts were to occur when the

15-day average price was at US 120 cents per pound and US 115 cents per pound respectively. Quotas were to increase by one million bags at US 140 cents per pound and US 145 cents per pound.

While producers and most ICO council members welcomed the outcome, consumers - especially the United States - were dissatisfied. The United States criticized the failure of the session to come to grips with issues which were creating market instability. They also argued that the quota was too low. A 61 million bag figure was proposed, but rejected. The United States (in October 1985) was reviewing its continued participation in the agreement.

In October 1985, the ICO 15-day indicator price was US119.29 cents a pound.

In November, as a result of the problems being experienced in Brazil, the ICO 15 day indicator price reached the quota release point of US140 cents per pound. Consequently there was a million bag increase in the ICO's October-December quarter export quota.

Early in January, the ICO's 15 indicator price soared to US186.53 cents per pound.

As a result of these price movements ICO export quotas were suspended in February 1986.

The most recently available ICO 15 day indicator price quotation (March 1986) was around US198 cents per pound.

This translates into a Papua New Guinea price of around K4100 per tonne (the March monthly average coffee price).

Problems with the agreement

Although coffee prices are trading at near record levels, the ICA is not without its problems. It is frequently criticized for setting inappropriate export quotas and for failing to control black market activities. After completely suspending export quotas in February, the ICO may find it impossible to regain control once the market overcomes the effect of the Brazilian crisis.

The recent collapse of the International Tin Agreement has called into question the effectiveness of international commodity agreements. Commodity agreements were initially designed to stabilize prices and supplies and hence protect both consumers and producers from the effects of bust/boom cycles. Both groups enthusiastically embraced these concepts in the 1970s. Now, however, little common ground is to be found.

A number of factors have emerged over the past 20 years that are serving to undermine traditional demand/supply trade cycles. These include flexible exchange rates; speculative investment in commodity futures markets; the influence of the Organization of Petroleum Exporting Countries (OPEC); protectionism; and a heavy reliance upon the United States dollar as the currency base for international trade.

Many producing countries are in a difficult position. If they do not accede to consumer demands for more realistic price support ranges they run the risk of commodity agreements, and hence prices collapsing. Should this occur, their foreign exchange earnings would be heavily reduced. The implications of such an occurrence would be drastic.

One important problem for the ICO is the increasing dissatisfaction of the United States with the agreement. Its announcement at the end of 1985 that it was considering withdrawing from the market caused a great deal of concern. The recent experience of the International Cocoa Agreement (of which the United States is not a member) indicates the problems of such agreements which do not involve the largest world consumer.

Another problem with the agreement, was the large discrepancy between member and non-member countries. Several consuming member countries have withdrawn from the agreement over the past three years to take advantage of lower prices outside of the agreement. The future of the agreement after the market recovers from the current increase in prices remains uncertain.

Appendix 3

Coffee Rust Threat to Australia

The infant but prospering coffee industry on the Atherton Tableland came under immediate threat with the outbreak of coffee rust in Papua New Guinea. This threat has existed not since the discovery of rust in Papua New Guinea in late April 1986, but since its arrival on a date at present unknown.

The threat exists in the passive and accidental carriage of the spores of the fungus to Australia by travellers, their baggage, and other goods and products, as well as by wind-blown spores.

If spores do arrive in Australia from Papua New Guinea, they need not only directly reach the plantations on the Atherton Tableland. Other coffee is already present in Australia in the form of isolated coffee bushes or groups of bushes grown for ornamental and interest purposes in some of the higher rainfall coastal areas from North Queensland to Southeast Queensland and into New South Wales.

If infection occurred on even one such coffee bush, a high proportion of which is Arabica the number of rust spores produced on that bush may be sufficient to infect other isolated coffees, and eventually to reach Australia's present and potential coffee-growing areas.

Therefore it would be desirable for Australia, through the Queensland Department of Primary Industries, to accelerate research

into, and the production of, improved coffee lines, especially those with resistance to known races of rust.

The quickest method of doing this would be through the already established channels of communication from Queensland to the main coffee research institutions in the world engaged in this research. Modern methods of multiplication would also need to be investigated to ensure that the quickest and safest (that is, most carefully scientifically controlled) measures were adopted.

The acceleration and expansion of the work already in operation in North Queensland could:

(i) assist Papua New Guinea in the situation which has now arisen there with the advent of coffee rust;

(ii) support and improve Australia's own developing coffee industry by the incorporation of new lines which may be of agronomic interest even if Australia remains free from rust; and

(iii) provide supplies of stock carrying resistance to some or all known races of rust in case coffee rust breaks out in Australia. This is a distinct possibility, as Australia has been under threat of coffee rust since it first arrived in Papua New Guinea, which may have been many months before its detection in April 1986.

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