Kava *(Piper methysticum)* in the South Pacific:
its importance, methods of cultivation, cultivars, diseases and pests

R. I. Davis and J. F. Brown

Australian Centre for International Agricultural Research
March 1999

The Australian Centre for International Agricultural Research (ACIAR) was established in June 1982 by an Act of the Australian Parliament. Its mandate is to help identify agricultural problems in developing countries and to commission collaborative research between Australian and developing country researchers in fields where Australia has special research competence.

Where trade names are used this does not constitute endorsement of nor discrimination against any product by the Centre.

ACIAR TECHNICAL REPORT SERIES

This series of publications contains technical information resulting from ACIAR-supported programs, projects and workshops (for which proceedings are not published), reports on Centre-supported fact-finding studies, or reports on other useful topics resulting from ACIAR activities. Publications in the series are distributed internationally to selected individuals and scientific institutions.

G.P.O. Box 1571, Canberra, ACT, 2601 Australia

Davis, R.I. and Brown, J.F. 1999. Kava (*Piper methysticum*) in the South Pacific:its importance, methods of cultivation, cultivars, diseases and pests.

ACIAR Technical Reports Series No. 46, 32p.

ISBN 1 86320 257 9

Technical editing: Apword Partners, Canberra
Design and art production: Design ONE Solutions, Canberra
Printing: Paragon Printers, Canberra

Acknowledgments

We wish to thank the Director and staff, particularly Ofa Fakalata, Tevita Holo and Paelata Nai, of the Tongan Ministry of Agriculture for providing support, encouragement and facilities for the kava dieback research project. Thanks are also due to the Director and staff, particularly Victor Tiollier, of the Vanuatu Department of Agriculture and Horticulture. We gratefully acknowledge the support and facilities provided for field trials by the Institut de Recherches du Café et du Cacao (IRCC) Research Station at Valeteruru, Espiritu Santo, Vanuatu. We also thank the Director and staff, particularly Jainend Kumar and Fauoro Vilsoni, of the Fiji Ministry of Agriculture, Fisheries and Forests and the Director and staff, particularly Semisi Semisi, of the Samoan Department of Agriculture, Forestry and Fisheries. The research on dieback of kava in the South Pacific was funded by the Australian Centre for International Agricultural Research.

R.I.Davis
J.F.Brown
[1999]

The Authors

Dr Richard I. Davis and Dr John F. Brown
Botany Department
University of New England,
Armidale, NSW 2351, Australia.

Current address for Dr Davis:
Australian Quarantine and Inspection Service (AQIS),
c/- Queensland Department of Primary Industries,
Centre for Tropical Agriculture,
PO Box 1054,
Mareeba,
Queensland 4880, Australia

Contents

Kava (*Piper methysticum*) in the South Pacific

This report discusses kava myths and ceremonies, the relative importance of kava as a cash crop, the kava plant and its cultivation, and the diseases and pests commonly found in kava gardens. It also describes the main kava cultivars grown in Fiji, Tonga, Vanuatu and Samoa, reports the results of field trials on the effects of shading on kava growth and yield, and compares the growth patterns and yields of 10 different kava cultivars in Vanuatu.

Background

Kava (*Piper methysticum* Forster f.) is an important traditional, ceremonial and cash crop in several island nations of the South Pacific — the Fiji Islands, Tonga, Vanuatu and the Samoas — and parts of Micronesia (e.g. Ponape) in the northern Pacific Ocean. It is one of the two main traditional drug plants used in the Pacific islands. The other is the palm *Areca catechu* L., the fruit of which is commonly called 'betel' or 'betel nut'. Betel nut-chewing, a common practice in Pacific island countries such as Papua New Guinea and Solomon Islands, and in many Asian countries, involves three ingredients—crushed nuts of the areca palm, leaves of *Piper betle* L., and lime (derived from burnt coral or shells).

Kava is used to prepare an intoxicating, non-alcoholic beverage (also called kava) made by mixing ground or masticated roots and stem bases with water. A lower grade 'mix' is sometimes prepared from stems. In some countries (e.g. Vanuatu) fresh plant material is used; in others (e.g. the Fiji Islands, Tonga and Samoa), dried tissue is ground to a powder to prepare the beverage (Fig. 1). Pacific Islanders typically drink kava at dusk, usually before the evening meal, but in some countries (e.g. Fiji) it is consumed throughout the day.

The beverage, known as *yaqona* in Fiji (pronounced 'yanggona'), *ava* in Samoa, *awa* in Hawaii, *sakau* in Ponape and *kava kava* in the Marquesas, is used for ceremonial and recreational purposes. Its consumption induces relaxation and later, sleepiness (Gatty 1956). It is believed to help break down social barriers, settle interpersonal conflicts, and enhance social ties, particularly among men. It is an integral part of religious, ceremonial, social, economic and political life in many parts of the South Pacific (Brunton 1989; Lebot et al. 1992; Singh 1992).

Kava is usually served in a half coconut shell, the total contents always drained in one draught, not slowly sipped. Proponents of it as a recreational beverage argue that it is preferable to alcoholic drinks because the drinker does not become angry, unpleasant, quarrelsome or noisy, as often happens after the consumption of alcohol. Cawte (1986) reported a typical response to kava use:

Figure 1. *Packaged kava powder prepared for the domestic, export and tourist markets (photograph by Chris Cooper).*

When people get intoxicated by kava they feel happy. They like to talk or to sing the traditional songs. They do not want to fight or chase after women. They just sit down and when drunk enough they go off to sleep.

In small villages the roots and stem bases are prepared by chewing fresh tissue, or by pounding dried portions in wooden, stone or metal mortars using wooden, stone or metal rods. Kava is usually dried in the sun before being pounded or ground to a powder (Fig. 2). In larger towns and cities, kava sold in shops and markets is commonly ground to a powder using mechanical grinders.

A kava bowl, a strainer and a cup, usually a half coconut-shell, are used to prepare and serve the kava beverage (Fig. 3). Traditional strainers are made from strips of *Hibiscus tiliaceus* L., but coconut fibre is also used. Nowadays, porous cloth such as cheesecloth is used to separate the solid residue from the beverage to be consumed, particularly during its preparation for social drinking (Fig. 4).

Kava has re-emerged as the traditional national drink in Vanuatu (Lamboll 1988) after being discouraged by early Christian missionaries. The resurgence is probably related to the emergence of nationalism after gaining independence from the United Kingdom and France, in 1980, successful promotion of the crop by the government, and the lack of money for alternative more expensive beverages such as beer (Minchinton and Brown, 1989a).

Kava is readily available in retail stores in urban areas and in *nakamals* (meeting-houses in villages and urban kava bars). Since the mid-1980s nakamals have become very common in such towns as Port Vila, and provide a significant source of employment and income.

A survey by Lamboll (1988) revealed 59 nakamals in Port Vila on the island of Efate, and nine in Luganville on Espiritu Santo. Similar kava bars called *kalapu kava* are common in Tonga (Fig. 5). In the nakamals of Vanuatu, kava is purchased by the coconut shell and is usually of relatively high concentration (a 'strong mix'). In the Tongan kalapu kava, drinkers usually pay an entrance fee that allows them to consume freely a (usually) relatively dilute beverage. In Fiji kava is consumed extensively by men and women of both indigenous Fijian and Indian populations, usually in private homes.

Australian Aboriginal communities have no traditional association with kava, though in the early

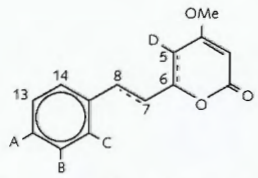
Figure 2. *Kava roots and basal stem portions being dried on a house roof on the island of 'Eua in Tonga (photograph by Dr E.J.Minchinton).*

Figure 3. *A small Fijian kava bowl with four legs, a 22-legged bowl from Samoa, and a coconut shell cup (photograph by Chris Cooper).*

Figure 4. *Musicians preparing kava for their personal consumption during a hotel performance on the island of Taveuni in Fiji.*

1980s some communities were introduced to it. At the time, visiting Fijian missionaries and Aboriginal church-people who had visited the Pacific Islands to observe kava use advocated its use in alcohol-troubled communities in Australia's 'Top End'. The contention was that it would overcome some of the social problems associated with alcohol abuse. Unfortunately kava also became a drug of abuse among some Aboriginal communities, possibly because of the lack of ceremonial and traditional constraints associated with its use (Cawte 1986; Smiles 1987). The effect supported Schenk's (1956) contention that drugs and poisons introduced from outside a region are far more deleterious than those with a long tradition in the area. Schenck referred to this as the 'law of alien poisons'.

Figure 5. *A kava bar (*kalapu kava*) on the island of Tongatapu in Tonga.*



		A	B	C	D	C5-C6	C7-C8
1.	kavain					–	=
2.	7,8-dihydrokavain					–	=
3.	5,6-dehydrokavain					=	=
4.	yangonin	OMe				=	=
5.	5,6,7,8-tetrahydroyangonin	OMe				–	–
6.	methysticin	O-CH_2-O				–	=
7.	dihydromethysticin	O-CH_2-O				–	–
8.	5,6-dehydromethysticin	O-CH_2-O				=	=
9.	5,6-dihydroyangonin	OMe				–	=
10.	7,8-dihydroyangonin	OMe				=	–
11.	10-methoxy-yangonin	OMe		OMe		=	=
12.	11-methoxy-yangonin	OMe	OMe			=	=
13.	11-hydroxy-yangonin	OMe	HO			=	=
14.	hydroxykavain				OH	–	=
15.	11-methoxy-12-hydroxy-dehydrokavain	OH	OMe			=	=

Figure 6. *Skeletal structure of kava lactones (from Lebot and Cabalion, 1988).*

The psychoactive ingredients in kava are believed to be a number of different lactones contained in resins extracted from plants. Skeletons for the 15 lactones currently identified in kava are generally substituted alpha pyrones or substituted 5, 6-dihydro-alpha-pyrones (Singh 1992) or, using the terminology of Lebot and colleagues (1992), 4-methoxy-2-pyrones with phenyl or styryl substitutes (Fig. 6). For further details of chemicals present in kava and their physiological effects, see Lebot et al. (1992) and Singh (1992).

Kava has considerable potential as a source of pharmaceutical compounds. The kava lactones act as sedatives, soporifics, analgesics, anticonvulsives, local anaesthetics, muscle relaxants and diuretics. They also show strong antimicrobial activity, particularly against fungi, including yeasts (Duve 1976; Lebot et al. 1992; Singh 1992). In certain regions of the highlands of the Indonesian province of Irian Jaya and in Papua New Guinea, kava is recognised by local tribespeople as an effective antibiotic to control minor skin infections, although it is not cultivated or used as a beverage.

Figure 7. *Pharmaceutical capsules containing kava root extracts marketed to treat nervous tension and sleeplessness, and to promote muscular relaxation (photograph by Chris Cooper).*

Some European and other pharmaceutical companies market specific kava lactones (e.g. kavain) and kava powder (containing several lactones) to treat human maladies, including unrest, nervousness, mental distress, 'inner excitement', psychological stress and lack of concentration (Fig. 7), and diseases caused by fungi. Traditionally kava has been used to treat gout, rheumatism, diarrhoea, asthma, venereal diseases and convulsive disorders (Duve 1976; Singh 1992).

Kava myths and ceremonies

Kava forms the basis of many Polynesian and Melanesian myths and legends.

In Tonga, for example, a specific story relates the first appearance of kava. According to legend, as reported by Gifford (1924), a chief named Loau from Haamea on the island of Tongatapu one day sailed to the small island Eueiki to visit his attendant Fevanga. Fevanga wished to honour his chief's visit with a great feast but could not do so because it was a time of famine. There was a kape plant (*Alocasia macrorrhiza* (L.) G. Don), but it would not provide sufficient food for the occasion. Fevanga and his wife Fefafa decided to kill and cook their leprous daughter to serve with the kape. Loau recognised the human flesh at the meal. He told the people not to eat the flesh, and instructed that it be planted in the ground and brought to him when it matured into a plant. Fevanga did that. The body grew into kava and sugarcane, each plant arising from a different part of the body. When the plants matured he noticed that a rat chewed on the kava and became paralysed, then it ate some sugarcane, and revived. When Loau received the mature kava plant, he instructed that a drink be prepared from it and consumed with due ceremony.

Lebot and colleagues (1992) recorded a story of how kava came to Samoa, as told by a grower from Fagaloa Bay on Upolu Island (reproduced with the permission of Yale University Press from the book *Kava the Pacific Drug*, by V. Lebot, M. Merlin and L. Linstom, ©1992 Yale University).

> Kava first came to Samoa through Tagaloa, the first matai, or chief. Tagaloa had two sons, Ava'ali'i and Sa'a'sa'ali'i. As Ava lay dying, he murmured to Sa'a that from his grave would come a plant of great value to the Samoan people. Ava died and was buried. Sa'a and his children watched the grave, and on the third day after Ava's burial, two plants were seen growing from the head of his grave. As Sa'a and the children watched, a rat came and ate the first plant. It then moved to the second one and began to eat, but quickly became intoxicated. The rat went staggering home as the people watched in astonishment. They named the first plant *tolo*, or sugarcane, and the second *ava*, in honour of the man from whom it sprung.

A popular story about kava's origin in Vanuatu tells of a jealous man who killed his wife and buried her in the garden. From her grave grew an unknown plant. A rat developed the habit of eating the root of the plant in the evenings, then falling into a profound sleep. Men thus discovered the virtues of kava, and said that because it had risen from the body of a woman, it must therefore be taboo (forbidden) for women to drink it (Bevan 1992).

On the island of Vanua Levu in Fiji, legend has it that kava appeared on the grave of a Prince Ranggona who had died a short time previously. The name *yanggona* was given the plant to honour the prince from whom it arose (Lebot et al. 1992).

Kava has great symbolic significance in the local customs of Melanesia and Polynesia. It is offered to the gods, spirits and ancestors as a sign of respect, to obtain their favour, to appease their resentment and anger if due respect has not been shown them, and to communicate with the supernatural world. It also plays a major ceremonial and social role in many island nations of the South Pacific. It is offered to such dignitaries as heads of state, chiefs and important people as a sign of respect, as a sign of sociability, to seal an agreement between two partners or to make an agreement publicly binding, and as a ritual sign of the sacred character of a place or an occasion. Most Pacific island nations have used in the past or currently use kava as an integral part of religious, ceremonial and political life. Exceptions include New Zealand, New Caledonia and most of Solomon Islands, where kava was not consumed.

There are three basic types of kava ceremonies. A full ceremony is used for very formal occasions such as

welcoming royalty or distinguished guests such as heads of state. A less formal ceremony is performed at meetings of village elders, chiefs and nobles, and there is the relatively informal kava circle at social occasions. But there are several variations in kava ceremonies. In Tonga, for example, *kava tolo* involves the presentation of whole plants at such ceremonies as the installation of priests and high officials. *Kava teletele* consists of a debarked stump and branch presented to people of high status at formal occasions. *Kava taumafa* and *kava ilo* are formal drinking ceremonies involving the king and nobles, respectively. A kava club or *kalapu kava* is for social, everyday, recreational drinking. A *kalapu kava Tonga* is a social event held in a kava club or church hall to raise funds for local charities. A *fai kava* is also a social event, but held in a private house where participants bring their own kava roots to prepare a beverage (Minchinton et al. 1989).

The kava drinking ceremony is an important feature of formal life in Fiji, Tonga and Samoa. Good accounts of the Tongan kava ceremony are given by Bott (1972) and Martin (1991). In Vanuatu kava drinking appears to be of importance socially but not ceremonially.

The yaqona (kava) ceremony in the Fiji Islands is a solemn event, and has several formal forms, one of which involving a guest and two chiefs was described in detail by Stanley (1986) (reproduced with some modification from D. Stanley's book *Finding Fiji*, Moon Publications, Chico, California):

> New tapa mats are spread on the floor, on which is placed a hand-carved wooden bowl (called a *tanoa*). Cowry shells decorate a long coconut fibre cord fastened to the bowl which is pointed towards the guest of honour. As many as 70 men form a circle in front of the bowl. The officiants are adorned with tapa cloth, fibre and coconut leaves, their bodies smeared with coconut oil, their faces usually blackened. The guests present a bundle of kava roots (called *waka*) to their hosts along with a short speech explaining the purpose of their visit. The kava roots are accepted by the hosts who respond with a short speech of acceptance. The kava roots are then scraped clean and pounded in a mortar (called a *tambili*). In a chiefly ceremony the kava is mixed with water then kneaded and strained through hibiscus fibres (called *vau*). The mixer displays the strength of the beverage, which is often referred to as grog in Fiji, to the master of ceremonies by pouring out a cupful into the kava bowl. If the master of ceremonies considers the mix to be too strong he calls for water which is added to the mix. Again he is shown the consistency of the mix. If he is satisfied with its strength he says 'lomba' (squeeze). The mixer squeezes the remaining juice from the pulp, puts the pulp aside and announces that the kava is ready. He runs both hands around the rim of the tanoa and claps three times. The master of ceremonies then says 'talo' (serve). The cupbearer squats in front of the tanoa with a half coconut shell (*bilo*) which the mixer fills. The cupbearer then presents the cup to the guest of honour who claps once, drains it and everyone claps three times. The second cup goes to the attendant of the guest of honour who claps once and drinks. The man sitting next to the mixer says 'aa' and everyone answers 'matha' (empty). The third cup is for the first local chief who claps once before drinking and everyone claps three times after. Then the attendant of the first local chief claps once, drinks, and everyone says 'matha'. The same occurs for the second local chief and his attendant. After these six men have finished their cups, the mixer announces 'sa matha saka tu na yanggona, vaka turanga' ('the bowl is empty, my chief'), and the master of ceremonies says 'thombo' (clap). The mixer then runs both hands around the rim of the tanoa and claps three times. This terminates the full ceremony, but then a second bowl is prepared and everyone drinks. During the first bowl, complete silence must be maintained.

The significance of kava in the life of Pacific Islanders is demonstrated by the fact that the altar in the Roman Catholic Cathedral in Nuku'alofa has the form of a large kava bowl (Fig. 8).

Figure 8. *An altar in the form of a kava bowl, St Mary's Cathedral, Vuna Road, Nuku'alofa, capital of the Kingdom of Tonga.*

Economic significance as a cash crop

Kava is a major cash crop in Fiji, Tonga, Vanuatu and Samoa, giving higher economic return per hectare than most alternative crops. Further, because it is a traditional crop, growers are generally familiar with its most suitable cultural practices, in contrast to those of newly introduced cash crops such as vanilla (*Vanilla planifolia* Andr.) and Japanese pumpkin or squash (*Cucurbita maxima* Duchesne), which require significant extension input. It is difficult to obtain quantitative, up-to-date information on the economic importance of crops in the Pacific Islands — the data presented here were obtained from such publications as agricultural censuses and annual reports of relevant ministries of agriculture, and personal communications. The following account provides a perspective of how kava fits into the economy of selected Pacific Island nations.

The Fiji Islands

Kava is an important cash crop in many regions of Fiji, and gives a greater economic return than alternative crops such as cassava (*Manihot esculenta* Crantz) and taro (*Colocasia esculenta* [L.] Schott and *Xanthosoma* spp.). Moreover, it can be interplanted with other profitable, quick-return crops such as taro which provide shade for it during the sensitive establishment stages of growth (Brown et al. 1989). Gross return from one hectare of kava is considerably more than most alternative crops available to farmers (Table 1).

Kava is usually grown in small plots in all parts of Fiji, although stands are more prolific in the Eastern and Northern Divisions. It is cultivated mainly by many small farmers (Table 2). A survey by Brown and colleagues (1989) noted only two large holdings; one of 10.5 ha on the island of Taveuni, the other of 12.5 ha at Savu Savu on the island of Vanua Levu.

Kava production varies annually depending on seasonal weather conditions and the incidence of a dieback disease which is its single most important constraint in Fiji and other Pacific islands. Area planted to kava, the amount harvested and its value, and farmgate prices for roots (*waka*) and stems (*lewena*) are shown in Table 3.

Until recently, most kava produced in Fiji was consumed locally, much of the demand for traded kava being in the Suva–Nausori urban corridor, the Lautoka and Nadi urban areas, and some outer islands (Fig. 9). In some seasons, some of the crop was exported to New Zealand (P. Turner, New Zealand kava importer, pers. comm.), Tonga and Samoa (Sofer 1985). By 1998, however, a large increase in demand for kava to satisfy export markets for pharmaceutical use had led to a dramatic rise in its price. Domestic market prices were up to three times greater than in 1994.

Table 1. A comparison of gross economic returns for kava and other selected crops in the Fiji Islands (from Kumar et al. 1998).

Crop	Gross margin (F$/acre)[c]	Gross margin (F$/person /day)
Kava	26 000–31 000	75–85
Sugarcane	500–600	6–9
Copra	185–195	3
Cocoa (bulk)	110–130	4–5
Ginger (mature)	2 900–3 100	17–20
Ginger (immature)	1 700–1 900	11–13
Papaya	3 000–3 300	26–30
Mango	8 500–9 500	38–42
Pineapple	6 900–7 300	21–25
Vanilla	1 200–1 600	7–10
Masi[a]	3 500–3 800	31–35
Voivoi[b]	2 100–2 400	18–22
Anthurium	37 000–41 000	53–58
Taro	1 400–1 600	14–16

[a] Masi (*Broussonetia papyrifera* Vent.) is the paper mulberry and is used to make tapa cloth in the Pacific Islands

[b] Voivoi or pandanus (*Pandanus caricosus* Spreng.) is a plant used to weave mats

[c] Currency conversion rates relative to one Australian dollar on 16 May 1998 were United States of America $0.627, Fiji Islands $1.250, New Zealand $1.169, Tonga Pa'anga 0.891, Vanuatu Vatu 76.68 and Samoa Tala 1.846

Table 2. Area, plot size, number of farms and distribution of kava in the Fiji Islands.[a]

Division	Pure stands (ha)	Mixed stands (ha)	Average size of pure stand crops per farm (ha)	No. of farms	Production in 1984 (t)
Western	220	51	0.18	1 076	400
Central	116	192	0.12	1 934	600
Northern	293	415	0.21	2 280	1 400
Eastern	314	821	0.12	3 981	2 000
Total/mean	943	1 479	0.16	9 271	4 400

[a] Data from Chandra (1983) and Fiji Ministry of Primary Industries *Annual Report* for 1984

Table 3. Area planted, amount harvested, value and farmgate prices of Kava 1990–94 (from Kumar et al. 1998).

Year	1990	1991	1992	1993	1994
Area planted (ha)	4 266	1 879	1 378	1 921	4 200
Production (t)	2 582	852	166	1 181	398
Number of farmers	12 605	—[a]	12 994	12 994	14 094
Value (million F$)	20.66	—[a]	—[a]	9.45	3.18
Farmgate price for roots (F$/kg)	8.50	9.00	10.00	11.00	11.50
Farmgate price for stems (F$/kg)	5.50	6.00	7.00	8.50	9.00

[a] Data not available

Tonga

The total value of kava to the economy of Tonga is difficult to estimate. The 1985 agricultural census estimated that 1489 households (15% of total households) planted about 141 hectares of kava. Of these households, 341 harvested 34 ha in 1985 which produced 279 t kava stumps and roots (Mulk 1988). It was estimated that a mean of 1640 plants/ha was grown on this 141 ha, suggesting a kava population of 231 240 plants in 1985. Rathey (1984) estimated 1982 kava production at 104 t from 44 ha, giving a mean yield 2.36 t/ha.

It is possible to trace kava sold on the domestic market in Nuku'alofa (Talamahu market) or through the Commodities Board to the export market. The value of kava sold at kava clubs or privately is unknown, although most sold to kava clubs in Nuku'alofa is probably purchased from the Talamahu markets. In 1985 the traceable worth of kava to the economy was T$306,487 (Table 4). However, the 1985 agricultural census estimated 279 t harvested that year (Mulk 1988), which, if it had sold at 1985 market value (T$23.72/kg), could have been worth as much as T$6.6 million to the economy.

Revenue from kava domestic market sales is less than that from other cash crops such as watermelon (*Citrullus lanatus* [Thunb.] Matsum and Nakai), yams (*Dioscorea alata* L.) or Japanese pumpkin (called Japanese squash in Tonga), but the value per unit weight is greater for kava (Table 5).

Gyles and co-workers (1988) compared the economics of growing banana, kava and vanilla and found kava to be the most profitable crop in return per hectare (Table 6). Their values may be overestimates, as they were based on crops that had been fertilised and sprayed to control pests. Most kava growers do not apply fertilisers nor biocides.

Table 4. Economic value of kava in Tonga,1985.

Market	Quantity of kava (t)	Revenue (T$)
Domestic	12.630	299 584
Export	0.291	6 903
Total	12.921	306 487

Table 5. Domestic value of cash crops in the Talamahu market at Nuku'alofa, Tonga in 1987.[a]

Crop	Quantity (t)	Average Price (T$/kg)	Gross worth (T$)
Kava	12.65	16.32	206 488
Bananas	524.09	0.18	94 336
Watermelons	1 204.83	0.50	602 415
Yams	338.01	1.37	463 074

[a] Data from the Ministry of Agriculture, Fisheries and Forestry, Planning Unit for the Talamahu Market Report for 1987

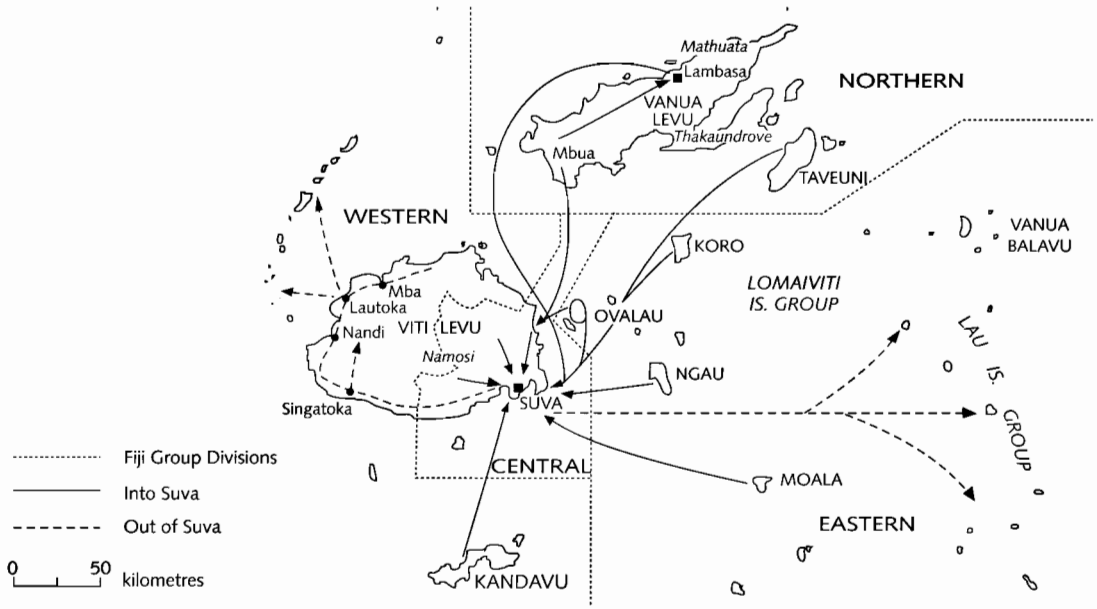


Figure 9. *Movement of kava to and from the main production centres in the Fiji Islands (from Sofer, 1985).*

Table 6. Estimated value and production costs of three major cash crops grown in Tonga during 1986[a]

	Bananas	Vanilla beans	Kava
Value (T$/kg)	0.32	12	18.21
Yield (kg/ha at 5 years)	85 561	778	6096
Production costs (T$/ha)	18053	1581	7530
Net profit (T$/ha)	9327	7755	103478

[a] Data from Gyles et al. (1988)

Vanuatu

Kava is an important domestic cash crop in Vanuatu (Lamboll 1988), although less important to the economy than cash crops such as cocoa and coconut (Table 7). In 1987 kava worth six million vatu was exported to France, New Caledonia and Australia (Lamboll 1988). Estimates of sales to European pharmaceutical companies for lactone extraction vary. Lamboll (1988) stated that 10 t dried kava was exported in 1987, though Lebot and colleagues reported that the French pharmaceutical industry purchased an average of 30 t dried kava rootstock annually from Vanuatu, and that the market remained stable, showing little fluctuation during the 10 years 1980–90.

The crop has considerable potential for development in Vanuatu (Lebot and Cabalion, 1986).

Kava, even grown in subsistence gardens in Vanuatu, competes economically with other commercial crops. Lebot and co-workers (1992) calculated that in commercial kava gardens, assuming planting density 1000/ha, yield of 10 kg/plant fresh rootstock and farmgate price US$1.00/kg, net income/ha after four years would exceed US$7000 (i.e. US$10 000 gross income minus $2856 materials and labour).

A statistical survey undertaken by the Vanuatu Ministry of Agriculture showed that four of the 21 kava-growing islands supplied about 87% total crop yield (Table 8).

Fresh kava is a perishable product that deteriorates after harvest. Consequently, in Vanuatu where fresh kava is used in preference to dry, the harvested roots must reach the markets as quickly as possible. Various middlemen are usually involved to arrange air or sea transport from the outer islands to the major population centres (e.g. Port Vila and Luganville) and then truck transport from wharves and airports to the final destinations. A typical marketing sequence is shown in Figure 10.

Table 7. Comparative cash crop income in Vanuatu in 1985 (from Lebot and Cabalion, 1988).

Crop	Income per person-day (vatu)[a]	Net income/ ha/year (000 vatu)	Price/t (000 vatu)
Kava	2 515	178	587
Vanilla	1 771	283	2 942
Cardamom	1 137	203	972
Garlic	1 083	290	138
Pepper	903	161	279
Cocoa	896	63	147
Coffee	800	75	267
Ginger	688	315	160
Copra	500	30	45

[a] calculated by dividing net income/ha by the number of workdays required over the full crop cycle.

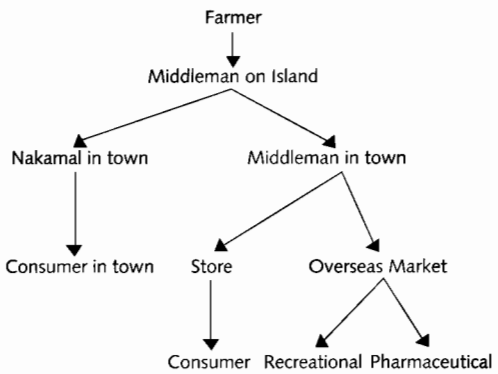


Figure 10. *Marketing channels for kava in Vanuatu (reproduced with the permission of Yale University Press from the book* Kava the Pacific Drug, *Lebot, Merlin and Lindstrom, © 1992 Yale University).*

Samoa

Kava is an important Samoan domestic and export cash crop, grown by subsistence farmers and larger commercial growers. Its value is difficult to estimate as accurate data are not readily available. Most information reported here is based on personal communication.

Powdered kava is exported to the Pacific Rim markets of Australia, New Zealand and the USA where it is purchased by expatriate islanders. It is also exported to neighbouring Pacific Island countries such as Fiji. One commercial company in 1988 exported 42 t chips, roots and powder (T. Bourke, pers. comm.).

Most kava in Samoa (about 65%) is grown on Savai'i, where production is widespread. The remainder is grown on Upolu Island, principally in districts such as A'ana, Fagaloa and Lalonea. Fagaloa is a traditional kava-growing district of nine villages, each having 10–15 farmers with 600–1000 plants each (Alo Fania, pers. comm.), that is, there are 90–135 growers and 54 000–135 000 kava plants in the Fagaloa district.

Table 8. Estimated number of kava plants in Vanuatu by island, 1984.[a]

Island	Households	Plants	Plants/household	Total plants in Vanuatu (%)
Ambae	1 821	249 846	137	10
Maewo	439	71 339	163	3
Pentecost	2 234	823 724	369	32
Paama	569	43 813	77	2
Epi	609	112 056	184	4
Tongoa	671	169 092	252	7
Tanna	3 487	1 001 629	287	38
Other islands	—[b]	134 136	—[b]	4
Total/mean	9 830	2 605 635	210	100

[a] Data from Marshall (1986) and Lamboll (1988)
[b] Data not available

Cultivation

Kava is a hardy, relatively slow-growing perennial shrub belonging to the pepper family (Piperaceae). It develops a stump (thickened underground portions of the stem and crown) at its base from which several single stems arise (Fig. 11). Plants reach a height of 2–3 metres at the time of harvest, usually 3–5 years after planting (Fig. 12).

Kava produces an infertile inflorescence that sets no seeds. Plants therefore are vegetatively propagated from cuttings taken from mature stems. An embryological study undertaken by Prakash and colleagues (1994) showed that most plants bore only male flowers and that pollen grains appeared to be healthy and capable of germination. Female flowers also appeared to develop normally. It was suggested therefore, that the lack of fruit formation in kava is not because of deficiencies in its embryological development, but may be due to a simple self-incompatibility mechanism.

New growth (shoot and root tissue) develops from stem nodes (buds occur at the axils of abscised lateral branch scars) several weeks after the cuttings are buried (usually at 5–10 cm depth) in soil or other growth media. Planting directly into the field usually involves planting horizontally in each hole two, three, or four cuttings, each having one or two nodes. Establishment rates in the field are often low.

The survival rate improves if plants are transplanted from polythene bags or pots into the field after 2–3 months growth in a nursery, when root systems are well developed. Plants are sometimes propagated from cuttings of 3–4 nodes planted vertically in deep holes (e.g. on Pentecost Island in Vanuatu). Organic mulch is often applied to the plant bases.

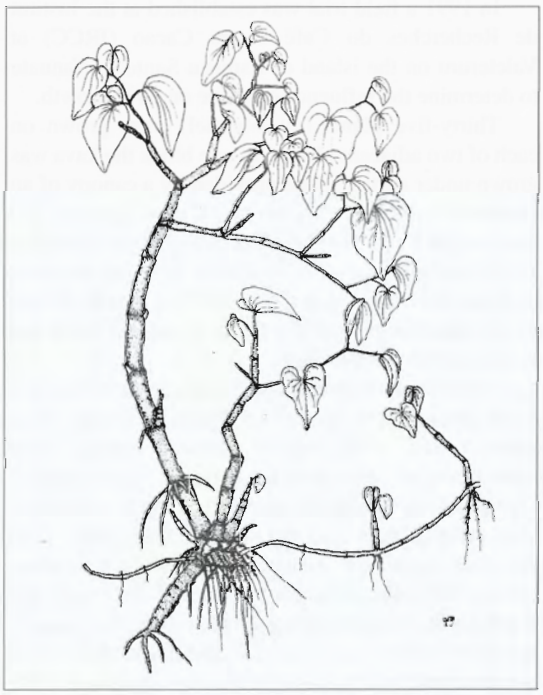


Figure 11. *General appearance of a kava plant (drawing by Dr Gayuh Rahayu).*

Figure 12. *A four-year-old kava bush in Fiji.*

Effect on emergence of age of nodes used for propagation

In 1992 the authors conducted a trial to determine the rates of emergence from planting material of different ages.

Mature stems typical of those used by kava growers for propagation were cut from 3-year-old plants (cv. kula) grown on the island of 'Eua in Tonga. Each stem consisted of 15 nodes, each approximately 2 cm in diameter. Individual nodes were cut from different positions on the stems (to represent nodes of different ages), and the ends of each node sealed in wax to reduce desiccation and infection by pathogenic micro-organisms.

The nodes were then planted horizontally at a depth of 5 cm in fumigated soil in polythene bags and placed under 50% shadecloth. Two groups of 25 stems each having 15 nodes were treated this way, one set cut and planted in March, the other in August.

It can be seen from Table 9 that when nodes used for propagation were grouped according to position on the stem, emergence rates from the oldest five nodes cut from the base of the stem were lower than those of the middle five and the five youngest nodes. This difference was significant ($P \leq 0.001$) for the March plantings but not for those in August, although the trends were similar.

Table 9. Effect of the age of propagating nodes of kava on subsequent emergence rates from soil.

Position of node on stem[a]	Cuttings that formed plants (%) Planted in March[b]	Planted in August
Basal nodes (oldest)	20[c]	39[c]
Middle nodes	49[d]	60[c]
Apical nodes (youngest)	60[d]	56[c]

[a] Each treatment consisted of 25 replicates each of which consisted of five single-node propagating pieces

[b] Figures within columns followed by the same letter are not significantly different at $P \leq 0.05$

Effect of shade on growth and yield

Kava is usually cultivated beneath a tree canopy. Protection from excess radiation appears to be especially important during the early growth stages. Young plants are usually shaded by protective cover crops such as taro, banana (*Musa* spp.) and cassava. The kava later grows and matures after the cover crop has been harvested. In Tonga, yam vines are often allowed to creep over the soil surface to protect small kava plants from solar radiation. In Vanuatu growers often train yam vines above the young kava plants on horizontal and vertical bamboo trellises, giving significantly more protection from sunlight. Kava is also commonly grown under coconut palms or in conjunction with cocoa and coffee during their establishment phase.

On the island of Efate in Vanuatu the authors observed kava deliberately grown under direct sunlight. The growers involved believed that such plants contained higher concentrations of kava lactones, perhaps due to lower plant water contents, though kava leaves exposed to direct sunlight often show a general yellowing of the upper surfaces that face the sun. In areas such as Mount Maugaloa on the island of Savai'i in Samoa, weather conditions are frequently overcast and wet, under which conditions unshaded kava grows well.

Kava plants subjected to water stress (e.g. during periods of drought) become wilted and leaf margins become necrotic. In severe drought, some growers prune field-grown plants extensively by removing large leaves to reduce evapotranspiration rates and therefore increase their chance of survival, a practice observed on the island of Efate in Vanuatu.

In 1991 a field trial was established at the Institut de Recherches du Café et du Cacao (IRCC) at Valeteruru on the island of Espiritu Santo in Vanuatu to determine the influence of shade on kava growth.

Thirty-five plants (cv. Melmel) were grown on each of two adjacent blocks. In one block the kava was grown under partial shade provided by a canopy of an unnamed cultivar of papaya (*Carica papaya* L.) intercropped with the kava. The papaya was planted at interplant spacings of 4 m on the day that the kava cuttings were planted in a nursery (2–3 months before being transplanted into the field). A second block had no protection from sunlight.

After about three years the kava was harvested, and plant growth and harvest weights recorded. Plant growth and yield were assessed using three measurements: (i) a stem number and length statistic obtained by measuring the number of stems over 0.3 m long on each plant and the mean of the length of the two longest stems on each plant; (ii) a leaf area statistic obtained by measuring the leaf area of the fourth leaf from the tip of the two longest stems using the equation length × width × 0.7; and (iii) the marketable (fresh weight) yield of kava was determined at harvest. Data recorded for each statistic were compared by analysis of variance and Duncan's Multiple Range Test.

The shaded plants grew larger and yielded more at harvest than the unshaded plants (Table 10). All plant growth statistics (except leaf area) and yield were significantly ($P \leq 0.005$) greater in shaded plants than those grown in direct sunlight.

Kava grows best on recently cleared forest land where large quantities of forest litter have been deposited and the soil is very fertile and high in organic matter. Recently cleared land also usually has low populations of soil-borne pests and pathogens. Consequently, most traditional growers in Vanuatu cultivate kava in gardens cut from the forest and rotate crops with bush fallow. On the island of Tanna in Vanuatu five or more years of kava cultivation are commonly alternated with 2–3 years bush fallow. Surveys in Vanuatu indicated that about 25% of total plants in kava gardens were ready for harvest at any given time, indicating that plants were harvested when they were about four years old.

Table 10. Effect of shading on growth and yield of kava plants (cv. Melmel), Vanuatu.

Growth/yield parameter (mean per plant)	Plants shaded by intercropped papaya trees	Plants grown in direct sunlight
Stems per plant	63.70[a]	40.60[b]
Stem length (m)	1.45[a]	0.98[b]
Leaf and stem fresh weight (kg)	16.00[a]	11.70[b]
Leaf area statistic (m^2)	0.02[a]	0.02[a]
Marketable yield (kg)	7.40[a]	4.40[b]

Figures within each row followed by the same letter are not significantly different at $P \leq 0.005$

Cultivars

Kava growers distinguish cultivars on the basis of morphological characteristics of the plant and on ancillary characteristics such as the smell and taste of the beverage, its physiological (psychoactive) effects on drinkers, and the region where the cultivar is thought to have originated. Morphological features used in classification include:

- plant stature (e.g. regular, erect, prostrate, dwarf),
- stem colour (e.g. light green, dark green, dark green with a purple tinge, purple and dark purple),
- relative internode length and thickness (e.g. short and thick, short and thin, long and thick, long and thin),
- lenticel distribution on stems (e.g. regularly spaced, irregularly spaced, concentrated near nodes),
- leaf colour (dark green, light green, yellow, green with a purple tinge),
- leaf pubescence or hairiness (e.g. hairy on both surfaces, hairy on abaxial (lower) surface only, non-pubescent).

It is of interest to note that most traditional systems of classifying kava and other plants use a generic name (e.g. kava) followed by one or more modifying or qualifying words that describe some detail of the particular cultivar such as colour, internode length or the believed area of origin. For example, traditional systems of classification and nomenclature in Fiji use words such as *vula* (white) and *loa* (black) to describe green and purple cultivars, *kasa* (internode), *balavu* (long) and *leka* (short). Thus cultivars have such local names as *Loa kasa leka* (purple stems, short internodes) and *Vula kasa balavu* (green stems with long internodes).

In Tonga, similarly, words such as *kula* (black), *hina* (white), *akau* (long internodes), *leka* (short internodes) and *fulufulua* (hairy) are used in kava nomenclature. Therefore cultivar names such as *kava hina akau* (green stems with long internodes) are used. Similar nomenclature systems are used in other areas of the South Pacific (Lebot et al. 1992).

Parham (1935) recognised five cultivars of kava in Fiji, three described as white-stemmed and two as black-stemmed. These cultivars were further distinguished on the basis of their habit, relative internode length and the size of leaf scars. Lebot and colleagues (1992) described 11 morphologically distinct cultivars in Fiji. Nine were described in Tonga by Minchinton and co-workers (1989). It is likely that cultivars grown in the Niua group of islands (Tafahi and Niuatoputapu) in the north of Tonga differ from those described in Tongatapu by Minchinton and colleagues (1989). Kava grown in the Niuas is predominantly green-stemmed, that found in Tongatapu mostly purple-stemmed.

In Vanuatu, believed by Lebot and colleagues (1992) to be the centre of origin of kava, 82 cultivars have been differentiated through morphological characters (Lebot and Lévesque 1989). Minchinton and Brown (1989b) described four cultivars commonly grown in Samoa (Table 11). Lebot and co-workers (1992) stated that seven cultivars are named in American Samoa, but only five cultivars recognised by Samoan growers. Only two of these, *Ava lea* and *Ava la'au*, are commonly grown.

A relatively recent introduction to some of the main kava-growing regions is a very similar but faster-growing cultivar of *Piper methysticum*, or possibly a different species of *Piper*. In Tonga this plant is said to have originated in Hawaii and is called *kava Hawaii*. On the island of Upolu in Samoa it is believed to have come from Fiji and is named *Ava Fiti*. The plant differs in appearance from the cultivars usually grown for consumption. Its leaves are pale green and elongated, and growth is characterised by a prolific development of new stems arising from adventitious

Table 11. Principal distinguishing features of some kava cultivars grown in Fiji, Tonga, Vanuatu and Samoa.

Cultivar name	Plant stature	Stem colour	Internode shape	Lenticel distribution	Leaf colour	Leaf shape	Leaf pubescence
The Fiji Islands (based on descriptions by Brown et al. 1989)							
Loa Kasa Leka	Regular	Dark purple	Short/thick	Regular	Dark	Regular	No
Loa Kasa Balavu	Erect	Dark purple	Long/thin	Regular	Dark	Regular	No
Vula Kasa Leka	Prostrate	Light green	Short/thick	Regular	Light	Regular	Yes
Vula Kasa Balavu	Erect	Light green	Long/thin	Regular	Light	Regular	Yes
Dokobana Vula	Erect	Light green	Long/thick	Regular	Dark	Regular	No
Dokobana Loa	Erect	Purple	Long/thick	Regular	Dark	Regular	No
Qila Leka	Regular	Dark green	Short/thick	Irregular	Dark	Elongated	Yes
Qila Balavu	Erect	Dark green	Long/thick	Regular	Dark	Elongated	Yes
Matakaro Leka	Erect	Green	Short/thick	Regular	Light	Undulate	No
Matakaro Balavu	Erect	Green	Long/thin	Regular	Light	Regular	No
Honolulu	Regular	Light green	Long/thin	Irregular	Light	Reg/round	No
Dama	Regular	Purple	Short/thick	Regular	Dark	Reg/round	No
Tonga (based on descriptions by Minchinton et al. 1989)							
Kula 'Akau	Erect	Purple	Long/thick	Regular	—[a]	—	No
Kula	Regular	Purple	Short/thick	Regular	—	—	No
Leka Kula	Prostrate	Purple	Short/thin	Regular	—	—	No
Hina 'Akau	Erect	Green	Long/thin	Regular	—	—	No
Hina	Regular	Green	Short/thick	Regular	—	—	No
Leka Hina	Prostrate	Green	Short/thin	Regular	—	—	No
Lau Fulufalua	Erect	Light green	Long/thick	Nodal	—	—	Yes
Ata	Dwarf	Light green	Long/thick	Nodal	—	—	Yes
Valu	Regular	Dark green	Long/thin	Nodal	—	—	No
Vanuatu (based on descriptions by Lebot and Lévesque, 1988)							
Malagro	Erect	Light green	Long/thin	—	—	—	No
Melmel	Prostrate	Green	Long/thin	—	—	—	No
Boroghu	Erect	Purple or Green	Long/thick	—	Purple	—	No
Kar	Erect	Purple	Long/thick	—	Purple	—	No
Kelai	Regular	Green	Long/thin	—	Light	—	No
Aigen	Erect	Light green	Long/thin	—	Light	—	No
Tudai	Regular	Dark green	Long/thin	—	—	—	Yes
Visul	Regular	Light green	Long/thin	—	Purple	—	No
Puariki	Regular	Light green	Long/thick	—	Light	—	No
Ahouia	Regular	Light green	Long/thin	—	Dark	—	No
Samoa (based on descriptions by Minchinton and Brown, 1989b)							
Le'a (Type A)	—	—	Long/thin	Many, random	—	—	—
Le'a (Type B)	—	—	Short/thin	Few, nodal	—	—	—
La'au (Type A)	—	—	Long/thick	Few, internodal	—	—	—
La'au (Type B)	—	—	Long/thick	Few, nodal	—	—	—

[a]— = Information not given

roots. The tissue has a characteristic aromatic smell. The plant is not popular with kava drinkers.

Some kava cultivars found in Fiji, Tonga, Vanuatu and Samoa and their morphological characteristics are given in Table 11.

Growth pattern and yield of 10 kava cultivars grown on Espiritu Santo, Vanuatu

A field trial was conducted 1991–94 at Valeteruru on the island of Espiritu Santo to compare growth patterns and yields of 10 kava cultivars. Similar trials were established at the same time in Fiji and Tonga. Severe dieback epidemics caused by cucumber mosaic cucumovirus (CMV) destroyed plants in the Fijian and Tongan trials before meaningful results could be obtained. Only a few plants in Vanuatu showed dieback symptoms.

In the Vanuatu trial, kava was transplanted into the field after 2–3 months growth in a nursery. The cultivars were planted in a randomised complete block design with four replications and an interplant spacing of 2 m. Each treatment replicate consisted of a single row of 10 plants. A border row consisting of a mixture of the 10 cultivars surrounded each replicate block. The trial was established on a flat site, intercropped with papaya to provide some shade. The local unnamed papaya cultivar was planted at an interplant spacing of 4 m on the day the kava cuttings were planted in a nursery (2–3 months before they were transplanted into the field).

The kava plants were harvested after about three years of growth in the field. Plant growth and yield were assessed using the measurements earlier described.

Considerable differences in growth and plant development were observed among the 10 cultivars (Table 12). Individual cultivars could be ranked in terms of plant vigour, using the plant growth statistics measured, and the amount of kava harvested. The most vigorous cultivar was Malagro, the least vigorous, Visul. Stem length index and yield were significantly greater ($P \leq 0.05$) in Malagro than in all other cultivars tested, and its stem numbers also significantly greater ($P \leq 0.05$) than all other cultivars except Melmel. With the exception of leaf area, which was among the largest, all growth indices and yield were lowest in Visul, which also had very yellow leaves compared with those of the other cultivars.

Table 12. Comparison of growth and yield of 10 kava cultivars three years after planting, Espiritu Santo, Vanuatu.[f]

Cultivar	Plant vigour measurement			Harvest fresh weight (kg)	
	No. of stems	Stem length (m)	Leaf area (m^2)	Leaf + stem	Stump + root
Malagro	67.8^{a}	1.9^{a}	0.12^{bc}	32.4^{a}	13.3^{a}
Melmel	62.8^{a}	1.4^{bcd}	0.19^{a}	16.4^{b}	7.5^{b}
Boroghu	40.5^{bc}	1.6^{b}	0.06^{de}	14.6^{bc}	5.6^{bcd}
Kar	33.8^{bcd}	1.6^{b}	0.10^{cd}	14.5^{bc}	5.9^{bcd}
Kelai	26.5^{d}	$1.3^{c}de$	0.15^{ab}	9.6^{cd}	4.6^{bcd}
Aigen	43.8^{b}	1.4^{bcd}	0.11^{bc}	17.4^{b}	6.8^{bc}
Tudei	29.5^{cd}	1.5^{bc}	0.13^{b}	12.2^{bcd}	5.8^{bcd}
Visul	23.5^{d}	1.1^{e}	0.15^{ab}	7.0^{d}	2.8^{d}
Puariki	24.5^{d}	1.2^{de}	0.08^{cde}	8.7^{cd}	3.9^{cd}
Ahouia	24.5^{d}	1.1^{e}	0.05^{e}	8.5^{cd}	3.8^{cd}

[f] Data presented are means per plant, calculated from four replicate plots, each of which contained 10 transplants of kava at the start of the trial. Means were compared by analysis of variance, followed by Duncan's multiple range test. Figures within each column followed by the same letter are not significantly different at $P \leq 0.05$

Diseases and pests

The most serious constraint to kava production in the South Pacific region is a dieback disease caused by cucumber mosaic cucumovirus (Davis et al. 1996). Other diseases appear to have no major impact on plant productivity in most seasons. Some insect and other pests have been shown to attack kava, though the kava weevil borer is the only insect recorded as causing serious damage. Some of the more common diseases and pests of kava are discussed below.

Diseases of kava

Dieback

Kava dieback was first reported in the scientific literature by Parham (1935), who described a 'wilt' disease in Fiji that in some instances caused crops to be abandoned, involving complete loss to growers.

The disease is characterised by a black rot of stems which eventually disintegrate (Fig. 13a). New shoots often arise from the base of affected plants, and cycles of dieback followed by regrowth are common. Ultimately, affected plants die. A symptom less frequently observed is wilting prior to stem rot and death. In recent years entire plantings have been almost destroyed by the disease in Fiji, Tonga, Vanuatu and Samoa.

Certain 'virus-like' leaf symptoms precede the stem rot. These include mosaic symptoms (a pattern of yellow, angular areas against a background of green tissue) together with one or more of the following—puckering along larger veins, crinkling and blistering of leaves (Fig. 13b). Small areas of internal necrosis associated with vascular tissue (Fig. 13c) often occur inside stems showing these 'virus-like' leaf symptoms, but no other external symptoms of infection are apparent at this stage.

Pares and colleagues (1992) showed that cucumber mosaic cucumovirus (CMV) was present in leaves showing mosaic, mottling and chlorotic symptoms. Davis and co-workers (1996) subsequently showed that CMV was widely distributed in kava plants in the main production areas of the South Pacific, and that symptoms of dieback developed on plants inoculated with CMV, usually within 3–4 weeks after leaf symptoms first became visible.

The most likely source of primary inoculum of CMV is infected planting material. Davis and Brown (1996) showed that at the beginning of an epidemic, infection foci were randomly distributed within plantings, indicating that primary infection originated either from infected planting material or from inoculum arriving from a distant source. As the

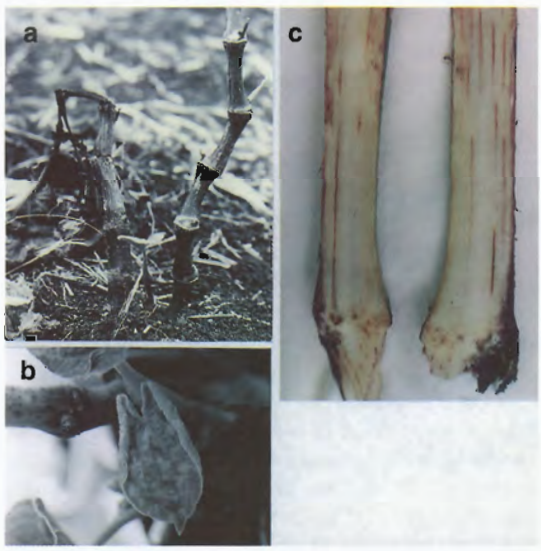


Figure 13. *Symptoms of kava dieback caused by cucumber mosaic cucumovirus (CMV): (a) severe dieback of stems and an attempt at regrowth; (b) 'virus-like' leaf symptoms showing mosaic and puckering of leaves; (c) internal necroses associated with vascular tissue in CMV-infected plants.*

epidemic progressed, secondary spread from initial foci to surrounding plants resulted in cluster expansion. CMV is known to be spread by aphids, including *Aphis gossypii* Glov., the species most often observed on kava plants in Tonga.

Davis and Brown (1996) showed also that CMV was not evenly distributed throughout kava plants. Not all nodes cut from infected plants tested positive for CMV. Distribution of the virus within stems cut from infected plants was erratic and followed no clear pattern. For example, symptomless stems taken from plants known to be CMV-infected showed 0%, 40%, 5% and 0% positive tests for CMV (using the double antibody sandwich–enzyme-linked immunosorbent assay or DAS-ELISA method) in leaves, petioles, stems and roots, respectively.

This restricted distribution of CMV is likely to limit the effectiveness of infected plants as sources of infection. The inability of CMV to spread systemically throughout the whole kava plant, together with the low emergence rate of CMV-infected planting material, may explain why kava dieback has not become a pandemic disease in the South Pacific. The restricted distribution in infected plants also suggests that a mild strain protection program is unlikely to be effective because the mild strain of the virus would not become systemic throughout the plant.

Applying certain cultural practices may provide a more effective means of dieback management. Careful selection of planting material would reduce the initial or primary incidence of CMV within crops, and, ideally, kava crops should be established using virus-free planting material. However, it would be impractical to implement a virus-free clonal certification scheme in the Pacific Islands. The next best option is to establish crops using planting material obtained from symptomless plants growing in regions where dieback is unknown or uncommon.

The elimination or reduction of populations of other susceptible hosts (sanitation) should also reduce the incidence of primary infections in kava gardens, though CMV has an extremely wide host range, infecting over 800 species from more than 80 plant families (Palukaitis et al. 1992). However, the host range of the CMV isolate from kava is uncertain, although it induces symptoms on several food plants grown in Tonga (Davis and Brown, 1996).

The need is to determine which common Pacific Island crop species and weeds are hosts to the CMV strain or strains that cause kava dieback, knowledge that may help develop effective disease management strategies.

It may be possible to reduce secondary spread of the disease within plantings by harvesting or removing and destroying diseased plants as soon as symptoms are detected. The removal of individual stems showing symptoms of virus infection may prove to be as effective as removing whole plants, in which case removal of whole plants could be avoided, minimising production losses. The value of either strategy has yet to be tested.

The spread of kava dieback appears to be facilitated by kava monoculture, monoculture being but one of many examples, of how human activity can lead to marked increases in the incidence of plant diseases (Brown 1997). Severe disease outbreaks in regions of intensive kava production occur in Fiji and Tonga. In contrast, the disease is not common in Vanuatu, where kava is mostly grown in small isolated plantations in a traditional mixed-species cropping system. CMV is transmitted in a non-persistent way by aphids, and the low incidence of dieback in traditional multicrop gardens may be partially explained by aphids feeding on non-host species in the mixed plant community and losing their infectivity. This may explain the lower number of initial infections originating outside the kava garden as well as the reduction of secondary spread within it. Growers should therefore be encouraged to maintain traditional growing techniques where kava plants are intercropped among other species.

Fungal diseases

Several fungi and a few bacteria have been found to be associated with disease symptoms in kava (Table 13), though in many instances pathogenicity tests have not been undertaken to prove a causal relationship between the presence of the fungus or bacterium and the disease symptom observed.

Anthracnose — symptoms associated with the presence of one or more species of *Colletotrichum*, particularly *C. gloeosporioides* (Penz.) Sacc., are common throughout the main kava-producing countries (Kumar et al. 1985; Brown and Minchinton, 1989). The pathogen causes small (usually less than 3 cm^2 in area), irregularly shaped dark sunken lesions on stems. The disease appears to have little effect on plant productivity.

Sphaerulina leaf spots — these are usually less than 1 cm in diameter (3–4 mm) and initially black in

Table 13. Fungi and bacteria associated with disease symptoms in kava in the Pacific Islands (from Dingley et al. 1981).

Fungus or bacterium associated with disease	Disease symptom	Location
Fungi		
Athelia rolfsii (Curzi) Tu and Kimbrough (sclerotial state *Sclerotium rolfsii* Sacc.)	Basal rot	Fiji
Cercospora sp.	Leaf spot	Fiji, Samoa
Colletotrichum dematium (Pers. ex Fr.) Grove	On dead tissue	Fiji
Colletotrichum sp.	On stems	Fiji
Cylindrocladium sp.	On roots	Fiji
Fusarium oxysporum Schlecht.	On roots	Fiji
Gibberella fujikuroi (Sawada) Ito (conidial state *Fusarium moniliforme* Sheldon)	On stems	Fiji
Glomerella cingulata (Stonem.) Spauld. and Schrenk (conidial state *Colletotrichum gloeosporioides* (Penzig) Penzig and Sacc.)	On dead leaf tissue	Fiji, Niue
Glomerella sp.	On leaves	Fiji
Lasiodiplodia theobromae (Pat.) Griff. and Maubl.	—[a]	Fiji
Nectria haematococca Berk. and Br.	On roots	Fiji
Neocosmospora sp.	—[a]	Fiji
Ophiolobolus sp.	Leaf spot	Fiji, Samoa
Phyllosticta sp.	On stems	Fiji
Pythium irregulare Buisman	On roots	Fiji
Pythium splendens Braun	On roots	Fiji
Sphaerulina sp.	Tar spot	Fiji, Tonga, Samoa
Stilbum sp.	On roots	Fiji
Bacteria		
Enterobacter aerogenes Hormaeche and Edwards	In vascular tissue of wilted plants	Fiji
Enterobacter cloacae (Jordan,) Hormaeche and Edwards	In vascular tissue of wilted plants	Fiji

[a]— information not given

Figure 14. *Leaf spot of kava thought to be caused by* Sphaerulina *sp.*

colour with their centres turning white surrounded by dark margins in mature lesions. The centres of lesions often drop out, giving 'shot-hole' symptoms (Fig. 14). The disease is believed to be caused by the Ascomycete *Sphaerulina* spp. (Dingley et al. 1981; Gerlach 1988). The disease is most prevalent in warm and moist environments such as that of Samoa, and occurs less frequently in the cooler and drier climate of Tonga.

Sclerotium rolfsii—often forms a white mycelium and pale yellow-brown spherical sclerotia (1–2 mm in diameter) on the external surface of kava roots and stem bases. Some authors (e.g. Singh and Nambiar, 1988) consider the fungus to be pathogenic on kava. However, in inoculation tests conducted by the authors where 300 sclerotia were placed adjacent to roots of potted kava plants, the fungus killed only plants whose roots had been severely injured prior to inoculation. *S. rolfsii* may play a role as a secondary pathogen of roots.

***Fusarium* spp.**—some species of the genus *Fusarium* are important pathogens of several tropical crop species. However, although *Fusarium* spp. can be readily isolated from kava roots, isolates tested by the authors, including isolates of *F. oxysporum*, *F. solani* (Mart.) Sacc. and *F. subglutinans* (Wollenweb. and Reinking) P. E. Nelson, T. A. Toussoun, and Marasas, were not pathogenic on kava.

Bacterial diseases

Soft-rotting bacteria of the genus *Erwinia* are readily isolated from kava (Butler 1974). Butler (1973) reported that *Erwinia* spp. were pathogenic to uninjured kava. However, Heinlein and colleagues (1984) were unable to demonstrate that *E. carotovora*

(Jones) Bergy et al. was pathogenic on kava. Pathogenicity tests undertaken by the authors showed that *E. carotovora* pv. *carotovora* (Jones) Dye 1923 produced a black soft rot when inoculated onto injured (but not uninjured) kava stems. The symptoms were similar to those of the black soft rot characteristic of kava dieback. The bacterium was capable of killing kava plants only after roots were severely injured. It is possible that this species may act as a secondary parasite under some circumstances.

Nematodes associated with kava

There have been no detailed studies of nematodes on kava. Most current knowledge is derived from the work of Orton Williams (1980), who conducted extensive nematode surveys throughout the South Pacific region. He showed that the following plant parasitic nematodes were present on kava:

— **spiral nematodes** (*Helicotylenchus rotundicauda* Sher, *H. dihystera* (Cobb) Sher, *H. multicinctus* (Cobb) Golden and *H. mucronatus* Siddiqi). This genus is the most commonly encountered plant-parasitic nematode on kava in the South Pacific. Almost all plantings were infested by at least one species;

— **reniform nematode** (*Rotylenchulus reniformis* Linford and Oliveira), often occurs in high populations and was present in 50–70% of the kava gardens surveyed in Fiji, Tonga and Samoa;

— **root-knot nematodes** (*Meloidogyne javanica* (Treub.) Chitwood, *M. incognita* (Kofoid and White) Chitwood and *M. arenaria* (Neal) Chitwood) are widespread throughout the region, and roots seriously debilitated by this group of nematodes were often observed.

Several other plant-parasitic nematodes were encountered less frequently. These included *Radopholus similis* (Cobb) Thorne, two *Pratylenchus* spp. (*P. coffeae* (Zimmermann) Filipjev and Schuurmans Steckhoven, and *P. brachyurus* (Godfrey) Filipjev and Schuurmans Steckhoven), several *Xiphinema* spp. and a number of Criconematids.

Senior Nematologist with the Queensland Department of Primary Industries, Australia, Dr G.R. Stirling, conducted in January 1990 a survey of nematodes associated with kava on the island of Tongatapu in Tonga. The following summary is derived from his unpublished report.

- Plant and soil samples were collected from kava gardens and nematodes were extracted from soil using a Whitehead tray (Whitehead and Hemming, 1965), and from roots by dissection or by aerating roots in water. *Meloidogyne javanica, M. incognita, Rotylenchulus reniformis, Radopholus similis, Helicotylenchus dihystera* and a *Xiphinema* sp. were recorded.
- It was difficult to recover fully active nematodes from roots. The lactones in kava responsible for its intoxicating effects when it is used as a beverage may be detrimental to nematodes and cause this inactivity.
- *Rotylenchulus reniformis* was recovered at populations of up to 1500 nematodes per 200 mL soil from Vaini Research Station.
- *Radopholus similis* occurred in soil around a wilting kava plant at another site at Vaini Research Station. Populations were 300–550 nematodes per 200 mL soil. Large numbers of burrowing nematodes were also observed in superficial cortical lesions on roots of this plant.
- *Meloidogyne* spp. were found in two of the five sites sampled. *M. javanica* was present at Vaini Research Station and *M. incognita* at another site on Tongatapu. Populations in soil were generally low, ranging 10–400 juveniles per 200 mL soil. Kava appeared to be highly susceptible to root-knot nematodes because as many as 20 developing nematodes and mature females were sometimes found in a 1-cm-long root segment. However, the large galls which occur on many susceptible plants were not observed on kava, and visible symptoms were restricted to a general swelling of roots (Fig. 15). When young roots were attacked, the portion of root on the distal side of the swelling was sometimes rotted. *Meloidogyne* females infected by the obligate parasitic bacterium *Pasteuria penetrans* were also observed.

Dr Stirling concluded that there is every likelihood that plant-parasitic nematodes, particularly *Meloidogyne* spp., *R. similis* and *R. reniformis* cause economic damage to kava crops. These nematodes are all serious pathogens of other crops in the tropics, and specific symptoms of *Meloidogyne* spp. and *R. similis* were observed on kava roots.

In pathogenicity tests conducted by the authors with *M. javanica*, where kava and tomato plants were inoculated under identical conditions, the inoculum levels used (10^5 eggs per plant) were sufficient to kill tomato plants. The extent of root gall development in kava was minor and would not have been expected to reduce plant growth, according to the assessment chart of Bridge and Page (1980).

*Figure 15. General swelling of kava roots caused by infection by root-knot nematodes (*Meloidogyne *spp.).*

Pests of kava

There have been few attempts to quantify the damage caused by individual pests, although some surveys of insect and other pests associated with kava have been made.

Insect and other invertebrate pests

The **kava weevil borer** (*Elytroteinus subtruncatus* Fairm.) is the only insect recorded as causing serious damage to kava. Surveys of kava gardens in Tonga during 1976 and 1979 (Fakalata 1981; Fakalata and Langi 1983) estimated that the weevil borer caused 28% damage to crops. The female weevils bore into the stems of kava and lay eggs. The larvae hatch and tunnel inside the stem (Fig. 16) causing it to become weakened and prone to infection by secondary soft-rotting fungi and bacteria.

Mites are small plant-fluid sucking pests. Two species have been observed on kava in Tonga; the two-spotted mite (*Tetranychus urticae* Koch.) and the bulb mite (*Rhizoglyphus echinopus* (Fumouze and Robin). When conditions are dry, large mite colonies can build up on

***Figure 16.** Damage to a stem of kava caused by the kava weevil borer (*Elytroteinus subtruncatus*).*

kava plants, causing significant damage in the field and in nurseries. Severely affected leaves become chlorotic, curled and necrotic on the margins.

Aphids are also plant-fluid feeding pests of kava. *Aphis gossypii* is the most common found on kava in Tonga. Extremely large colonies can become established, especially during dry weather. However, the most damaging aspect of aphid infestation is their role as a vector of CMV, the cause of kava dieback.

Mealy bugs (*Planococcus* spp.) are plant-fluid sucking insects which sometimes attack kava aerial parts (Fig. 17) and roots. Severe infestation can lead to defoliation, and in the case of root infestation, to a general unthrifty plant appearance.

Scale insects, which also feed on plant fluids, can occur in large numbers on kava stems. The nigra scale (*Parasaissetia nigra* Neitrer) and the coconut scale (*Aspidiotus destructor* Sign.) have been recorded on kava in Tonga (Minchinton et al. 1989).

Army worms (*Spodoptera* spp.) can cause damage in kava nurseries and are sometimes present in the field where they feed directly on foliage. This pest can cause complete plant defoliation.

The **giant African land snail** (*Achatina fulica* Bowditch) can damage kava crops if it transfers from its natural diet of detritus onto growing plants. The snail is present in Fiji, Vanuatu and Samoa, but has not yet become established in Tonga.

Figure 17. *Mealy bug infestation on a kava stem.*

Vertebrate pests and abiotic diseases

Rats sometimes chew the base of kava plants, causing stems to collapse.

Kava is highly sensitive to the phytotoxic effects of the salts in sea water and other water containing high concentrations of salts. Sea water can be blown several kilometres inland during cyclones and strong winds, and cause extensive damage to kava crops.

On the island of Tanna in Vanuatu, the authors observed extensive plant damage (marginal necrosis, curling and holes in leaves), attributed by several growers to acid rain and ash deposition from the island's active volcano (Mount Yasur).

References

Bevan, S. 1992. Vanuatu. Gadabout Guides, Carlton, Victoria.

Bott, E. 1972. Psychoanalysis and ceremony. In: La Fontaine, J.S. (ed.), The Interpretation of Ritual, Essays in Honour of A. I. Richards, Tavistock Publications, London, 205–233.

Bridge, J. and Page, S.L.J. 1980. Estimation of root-knot nematode infestation levels on roots using a rating chart. Tropical Pest Management 26, 296–298.

Brown, J.F. 1997. Plant pathology: an overview. In: Brown, J.F. and Ogle H. J. (eds), Plant Pathogens and Plant Diseases, Rockvale Publications, Armidale, 3–20.

Brown, J.F., Kumar, J. and Minchinton, E.J. 1989. Kava and kava diseases in Fiji. In: Brown, J. F. (ed.), Kava and Kava Diseases in the South Pacific. ACIAR Working Paper No 24, ACIAR Canberra, 10–27.

Brown, J.F. and Minchinton, E.J. 1989. Kava and kava diseases in the South Pacific: an overview and summary. In: Brown, J. F. (ed.), Kava and Kava Diseases in the South Pacific. ACIAR Working Paper No 24, ACIAR, Canberra, 1–9.

Brunton, R. 1989. The Abandoned Narcotic Kava and Cultural Instability in Melanesia. Cambridge University Press, Cambridge. 219p.

Butler, L.D. 1973. Yaqona wilt investigation. Annual Research Report for 1972, Department of Agriculture, Fiji, 132–133.

—— 1974. Common Economic Plant Diseases in Fiji. Ministry of Agriculture, Fisheries and Forestry, Fiji, 37p.

Cawte, J. 1986. Parameters of kava used as a challenge to alcohol. Australian and New Zealand Journal of Psychiatry 20:70–76.

Chandra, S. 1983. Agricultural Development in Fiji. Australian Universities International Development Program, 172p.

Davis, R.I. and Brown, J.F. 1996. Epidemiology and management of kava dieback caused by cucumber mosaic cucumovirus. Plant Disease 80:917–921.

Davis, R.I., Brown, J.F. and Pone, S.P. 1996. Causal relationship between cucumber mosaic cucumovirus and kava dieback in the South Pacific. Plant Disease 80:194–198.

Dingley, J.M., Fullerton, R.A. and McKenzie, E.H.C. 1981. Survey of Agricultural Pests and Diseases. Records of Fungi, Bacteria, Algae and Angiosperms Pathogenic on Plants in Cook Islands, Fiji, Kiribati, Niue, Tonga, Tuvalu and Western Samoa. Technical Report, Volume 2. South Pacific Bureau for Economic Co-operation, United Nations Development Programme and Food and Agriculture Organization of the United Nations, 485p.

Duve, R.N. 1976. Highlights of the chemistry and pharmacology of yaqona (*Piper methysticum*). Fiji Agricultural Journal 38:81–84.

Fakalata, O. 1981. Weevil pest on kava stems in Vava'u (Tonga). Alafua Agricultural Bulletin 6:38–39.

Fakalata, O. and Langi, T. 1983. Kava project profiles. Unpublished internal report of the German-Tongan Plant Protection Project, 1–9.

Gatty, R. 1956. Kava—Polynesian beverage shrub. Economic Botany 10:241–249.

Gerlach, W.W.P. 1988. Plant Diseases of Western Samoa. Samoan–German Crop Protection Project, Apia, Western Samoa. 215p.

Gifford, E.W. 1924. Tongan myths and tales. Bernice P. Bishop Museum Bulletin No. 8, Honolulu, 71–75.

Gyles, A. L., Sefanaia, S., Fleming, E.M. and Hardaker, J.B. 1988. Farm Management Handbook for Tonga. Tongan Ministry of Agriculture, Fisheries and Forests South Pacific Smallholder Project, 139p.

Heinlein, M., Kumar, J., Nambiar, V., Kaitetara, T. and Kashyap, D.M. 1984. Yaqona pests and diseases. Wilt and stem rot control in yaqona. Annual Research Report for 1983, Department of Agriculture, Fiji, 51–52.

Kumar, J., Singh, D.S., Kaitetara, T., Nambiar, V. and Kashyap, D.M. 1985. Yaqona: Pests and diseases. Yaqona disease complex. Annual Research Report for 1985 Department of Agriculture, Fiji. 44p.

Kumar, S., Kaitetera, T., and Mudaliar, T. 1998. Opportunities for the Production of Yaqona in Fiji for Export. Situation Analysis No. 1. Fiji Ministry of Agriculture, Forestry and Fisheries and Soil and Crop Evaluation Project, AusAID. Suva.

Lamboll, R. 1988. Kava in Vanuatu: the advent of a cash crop. Unpublished report, Vanuatu Department of Agriculture, Forestry and Livestock, 26p.

Lebot, V. and Cabalion, P. 1988. Kavas of Vanuatu. Cultivars of *Piper methysticum* Forst. Technical Paper No. 195, South Pacific Commission, Noumea, 191p.

Lebot, V. and Lévesque, J. 1989. The origin and distribution of kava (*Piper methysticum* Forst.f and *Piper wichmanii*. C. DC., Piperaceae): a phytochemical approach. Allertonia 5:223–280.

Lebot, V., Merlin, M. and Lindstom, L. 1992. Kava the Pacific Drug. Yale University Press Newhaven, 255p.

Marshall, A.D. 1986. Report on the Agricultural Census (1983/1984) Republic of Vanuatu. Part 1, The Results. National Planning and Statistics Office, Port Vila.

Martin, J. 1991. Tonga Islands—William Mariner's Account. Vava'u Press, Nuku'alofa, 399p.

Minchinton, E.J. and Brown, J.F. 1989a. Kava and kava diseases in Vanuatu. In: Brown, J.F.(ed.), Kava and Kava Diseases in the South Pacific. ACIAR Working Paper No. 24, ACIAR, Canberra, 51–62.

——1989b. Kava and kava diseases in Western Samoa. In: Brown, J.F.(ed.), Kava and Kava Diseases in the South Pacific. ACIAR Working Paper No. 24, ACIAR, Canberra, 63–70.

Minchinton, E.J., Holo, T. and Brown, J.F. 1989. Kava and kava diseases in Tonga. In: Brown, J.F.(ed.), Kava and Kava Diseases in the South Pacific. ACIAR Working Paper No. 24, ACIAR, Canberra, 28–50.

Mulk, S.M.I. 1988. Tonga Agricultural Census 1985. Kingdom of Tonga, Statistics Department, Government of Tonga, Nuku'alofa, Tonga, 131p.

Orton Williams, K.J. 1980. Plant Parasitic Nematodes of the South Pacific. Technical Report Volume 8, Commonwealth Institute of Helminthology, St Albans, 192p.

Pares, R.D., Gillings, M.R., Davis, R. and Brown, J.F. 1992. Cucumber mosaic cucumovirus associated with kava plants showing symptoms of dieback disease in Fiji and Tonga. Australasian Plant Pathology 21:169–171.

Parham, B.E.V. 1935. Wilt disease of 'Yangona'. Fiji Agricultural Journal 8:2–8.

Palukaitis, P., Roossinck, M.J., Dietzgen, R.G. and Francki, R.I.B. 1992. Cucumber mosaic virus. Advances in Virus Research 41:281–348.

Prakash, N., Brown, J.F. and Wang, Y. 1994. An embryological study of kava, *Piper methysticum*. Australian Journal of Botany 42:231–237.

Rathey, R.E. 1984. Agriculture in the Economy of the Kingdom of Tonga—Constraints, Resources, Farm Economics. Final report of the Agricultural economist. Ministry of Agriculture, Fisheries and Forestry Tongan–German Plant Protection Project, MAFF Planning Unit, 170p.

Schenk, G. 1956. The Book of Poisons (translated by M. Bullock). Weidenfeld and Nicolson, London.

Singh, P. and Nambiar, V. 1988. Yaqona: control of yaqona wilt disease. Annual Report for 1987, Research Division, Fiji Department of Agriculture, Ministry of Primary Industries, Suva.

Singh, Y.N. 1992. Kava: an overview. Journal of Ethnopharmacology 37:13-45

Smiles, S. 1987. Kava, the alcohol alternative (and why it's stronger in Vanuatu). Islands Business May 1987, 32–33.

Sofer, M. 1985. Yaqona and peripheral economy. Pacific View Point 26:415–436.

Stanley, D. 1986. Finding Fiji. Moon Publications, Chico, California. 123p.

Whitehead, A.G. and Hemming, J.R. 1965. A comparison of some quantitative methods of extracting small vermiform nematodes from soil. Annals of Applied Biology 55:25–38.