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BACTERIAL WILT OR BROWN ROT OF POTATO

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ABSTRACT

Bacterial Wilt of potato caused by Pseudomonas solanacearum *(Smith) and its control measures are discussed.*

KEYWORDS: *Bacterial Wilt,* Pseudomonas solanacearum, *contagious, brown rot*

INTRODUCTION

Bacterial Wilt (or Brown Rot) of potato is caused by a bacteria known as *Pseudomonas solanacearum* (Smith). Other names (synonyms): *Ralstonia solanacearum, Burkholderia solanacearum.*

Description: *P. solanacearum* is a rod-shaped gram negative bacteria commonly divided into five biovars and five races. Biovar 2-A, race 3 is the most common pathogen (disease causing organism) which causes Bacterial Wilt in potatoes (Jeffries 1998).

Distribution: *P. solanacearum* is distributed around the tropics and sub-tropics, reaching as far as 56° N (in Europe) and 38° S (in South America). In Papua New Guinea, it is wide spread in areas where potato is grown (Bang and Wiles *in press*).

Hosts: *P. solanacearum* has a wide range of hosts in more than 40 families of plants (Hayward 1991). Biovar 2-A, race 3 is more specific to potato and other related plants in the Solanaceae family such as tomato, capsicum, tobacco and egg-plant. Two other important hosts in PNG are banana and peanut

Transmission: The pathogen, *P. solanacearum* is spread in a number of ways.

1. Vegetative propagation. Use of infected seed potato tubers for planting.
2. By man (farmer) through contact of infected plant to healthy plant.
3. Use of tools. No proper cleaning of tools used in infected garden to healthy garden.
4. Other plant hosts which may be regarded as weeds and present in and near garden.
5. Soil - from previous infection.

SYMPTOMS

Wilting of a leaf or a side branch is the first sign of infection (Figure 1). If the plant is cut just above the ground and viewed, there would be browning of the vascular bundle, which is the inside centre of the plant where plant food and water is transported from the ground to the whole plant. If an infected tuber is cut, browning and necrosis or Brown Rot can be seen around the vascular ring (Figure 2).

A milky white ooze will come out of the cut stem if squeezed or dipped into a glass of water. This white ooze is made up of millions of the *P. solanacearum* bacteria, and may also be seen coming out of tuber eyes or vascular ring if a cut tuber is squeezed.

IMPORTANCE

Bacterial Wilt is a very serious disease and high yield losses in a whole potato crop may result from this disease. It is also highly contagious, which means the risk of infection is very high.

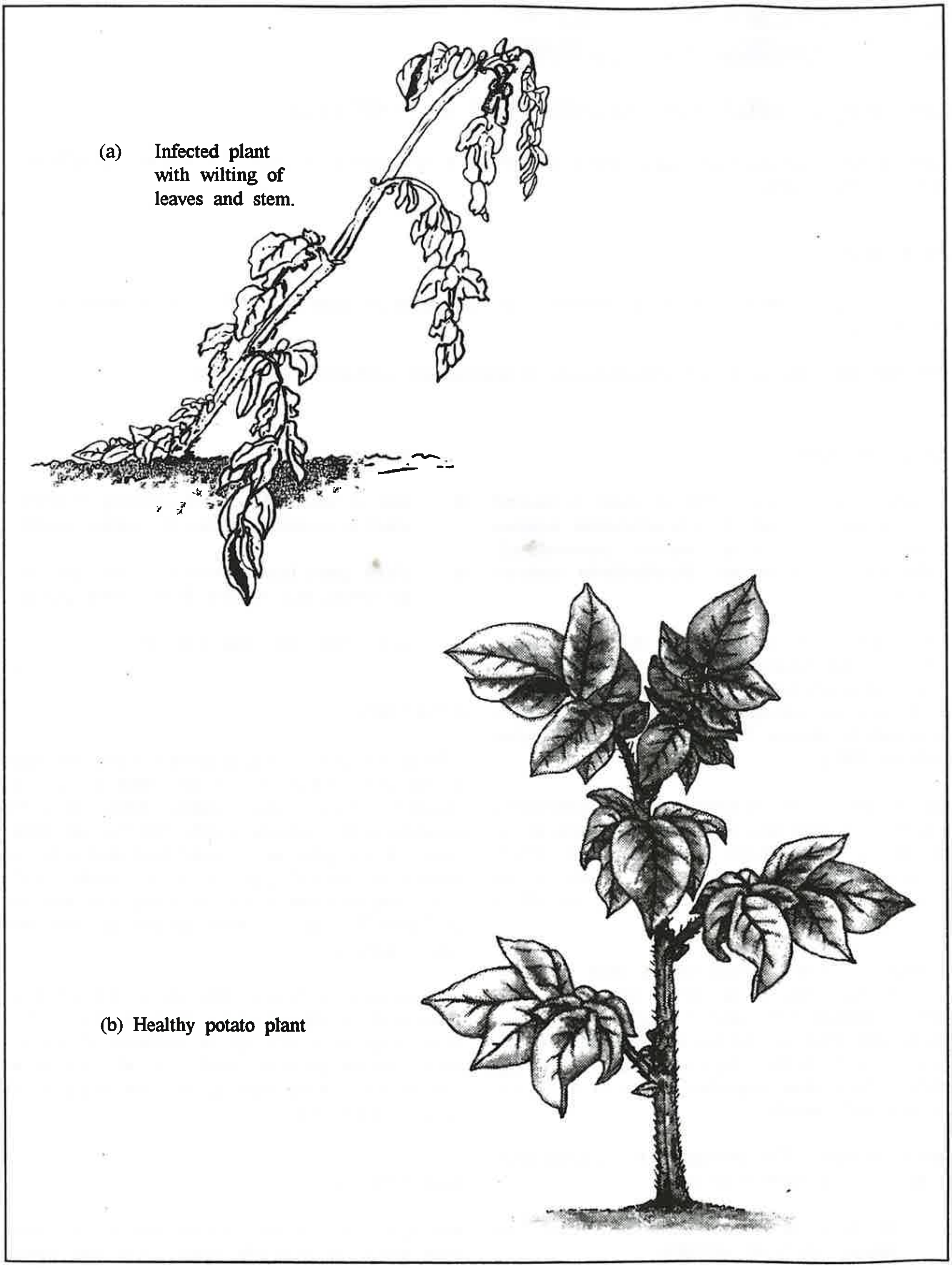

Figure 1. (a) Wilting of leaves and stem of infected potato plant. (b) Healthy potato plant.

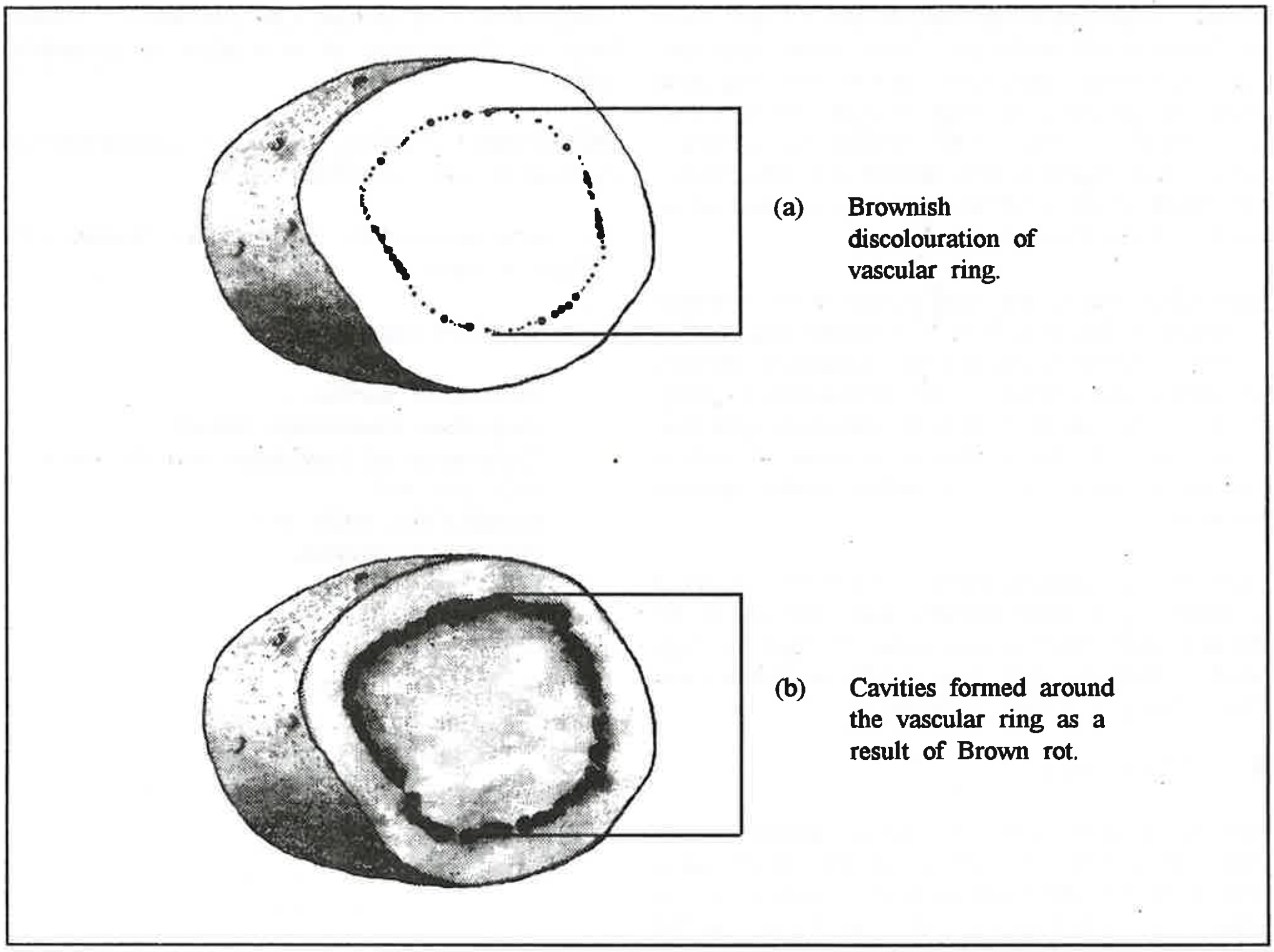

Figure 2. Brown rot of tuber around the vascular ring. (a) Brownish discolouration of vascular ring. (b) Cavities around the vascular ring.

The pathogen can be persistent in infected fields for a very long time.

CONTROL

There is no easy chemical control for this disease. The only effective method for potato at present is through gardening practises and the use of resistant potato varieties. However, no resistant potato varieties have been selected for PNG yet.

Farmers should carefully follow the following management procedures to effectively reduce the incidence of Bacterial Wilt.

1. New Seed Tubers

Always use new seeds not infected by Bacterial Wilt for planting. Get information from the nearest DPI office.

2. Disease Plants

Uproot the whole plant including the roots and burn or bury it away from the garden.

3. Disinfection

If you have to work in more than one garden, always wash and clean your feet and hands including all the tools used. DAL / DPI recommendation of 2 parts Formalin in 100 parts water for foot bath and sterilising of tools must be used. Get more information from your nearest DPI office for this.

4. Crop Rotation

Crop rotation means planting different crops during different times, one after the other, on the same piece of land. In between or before planting potato, other crops can be planted to give time for Bacterial Wilt to die out. Crops related to potato such as tomato, capsicum, tobacco and egg-plant must not be used for crop rotation. These crops are mostly in the same family as potato - Solanaceae. Banana and peanut are also important hosts of Bacterial Wilt so they should not be used as crop rotation crops.

Corn (*Zea maize*) has been shown to be effective in reducing Bacterial Wilt in infected land but, it is not a common practise for subsistent farmers to plant a whole field of corn (monocrop of corn). In this case, farmers should inter-crop (planting more than one crop on the same piece of land at the same time) corn and sweet potato (*Ipomea batatas*).

However, to seriously plant and obtain high yield of potato, it is recommended that corn should be planted after each potato crop. If there is high level of Bacterial Wilt, corn should be planted two times (Bang & Wiles *in press*).

5. Slope Land

On sloping land, potato should be planted on the lower slope first. If planted on the upper slope first, then rain water will wash the pathogen to the lower slope infecting the soil. Future crop on the lower slope will be spoilt.

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SELECTED SAGO-BASED TRADITIONAL FOOD OF PAPUA NEW GUINEA

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ABSTRACT

Sago is a staple food in the coastal flood plains of Papua New Guinea and is prepared in various forms. Eight sago-based traditional food are described here. They were obtained from a survey conducted from 1992 to 1994. These food included Dia, Kalua, Alung, Sago Fomo, Karamap Saksa, Kilikan, Mona Sagu, and Sagu Bamboo, Coconut, banana and peanut are normally combined with sago to improve the nutritional quality. Certain areas for upgrading these food are discussed.

KEYWORDS: *sago, improve quality, traditional, processing*

INTRODUCTION

Sago, an edible starch extraced from the trunk of the palm *Metroxylon sagu* is a valuable food for many communities in Southern Asia, Melanesian Islands, Micronesia, India, Sri Lanka, and Central and Southern Amerca (Cecil 1992). The area under wild sago palm has been estimated as 2.25 million ha of which about 1 million ha are in Papua New Guinea (PNG) where it is considered to be the centre of diversity for sago (Flach 1997). There are many type of sago palms in PNG and most sago palms are thought to be *Metroxylon rumphii* (Yatsugi 1986), although Shimoda & Power (1992) considered *M. sagu* and *M. rumphii* to be the same species.

Sago is used in almost all the coastal provinces in PNG. The traditional extraction of sago starch is physically demanding (Morauta 1982), a factor that is reducing sago production but emphasising the need to introduced efficient and effective tools. Shimoda & Power (1986) discussed the factors affecting starch content of sago, while Fujii *et al.* (1986) outlined approaches to improve the quality of sago starch. Power (1986) noted that in PNG, research and development efforts are needed to optimise sago starch processing with regard to technology, production and marketing. The success of such efforts will depend on finding uses for the improved sago starch within and beyond the production centre(s).

Two strategies could be adopted for increased utilisation of sago starch in PNG. One is to examine and adapt conventional processing of sago products and to upgrade traditional procedures for the manufacture of sago products (New 1986). However, the upgrading strategy must be aware that traditional food processing is noted for inefficient technology, ignorance of hygienic practices, lack of quality control, and insufficient understanding of the operations and processess involved (Sopade 1995). Although traditional products are relatively easily accepted by consumers, the type of product must be identified so that technology can be applied to its efficient processing. A step in this direction would generate a processing base for an important traditional food.

New (1986) described a range of sago-based food but the approach was more from the cookery standpoint and not particularly adapted for food processing studies. This is because such studies require itemising the unit operations and processes for clearer identification of the critcal steps. This is needed to identify the contributions of the steps to overall quality of the finished product. Such identifications help inventing appropriate machines for increased utilisation of sago starch. Hence, this paper uses flowcharts to describe some of these food and is hoped that more sago-based food or variations in those described will be reported as these long-term studies continue.

METHODOLOGY

A survey was conducted at the Papua New Guinea University of Technology, Lae and some women groups were asked about the traditional food that they were familiar with. Between 1992 and 1998, new food technology students were asked to describe the traditional food in their provinces. In some cases, personal interviews were conducted before the final flowcharts were formulated.

RESULTS AND DISCUSSION

Traditional Food

The following traditional food were complied.

Dia

Dia is a banana-sago pudding (Figure 1) common in Central Province. The banana improves the nutritional quality of the sago. Storing the pudding in coconut oil is reported to increase its shelf life possibly by providing a barrier between the pudding and air. The moisture content of the pudding is expected to be high and the likelihood of hydrolytic rancidity of the coconut will limit prolonged storage.

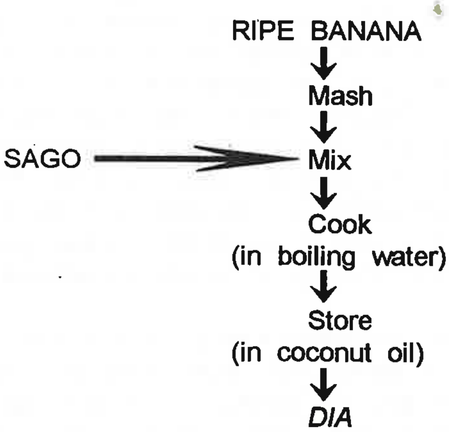


Figure 1. **Preparation of Dia**

Kalua

This is similar to Dia except that grated coconut and fish are added to the pudding (Figure 2). It is not stored in oil and is common in Morobe Province.

Alung

A sago-coconut product (Figure 3) that is dry-fried. Another form of the mixture is cooked in water and served with fish and vegetables. Both products are common in Madang and Morobe Provinces.

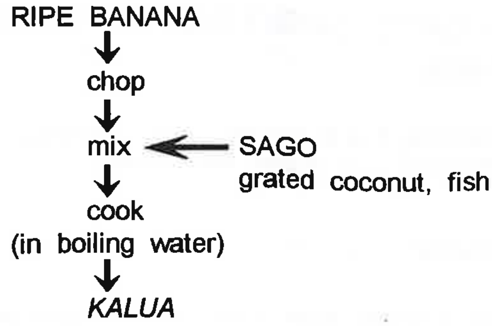


Figure 2. **Preparation of Kalua**

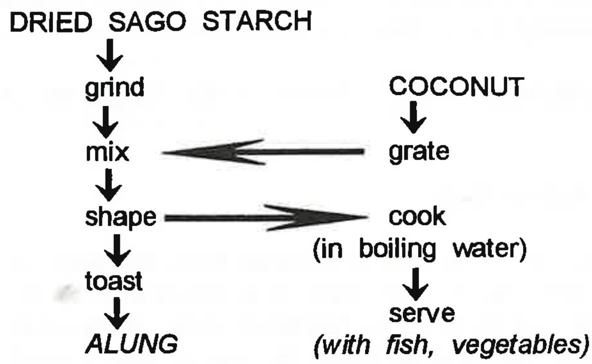


Figure 3. **Preparation of Alung**

Sagu Forno

Sago and water or coconut milk are mixed and roasted in a clay tray known as Forno with depressed compartments (Figure 4). The mixture is put into the Forno after pre-heating the trays. The residual heat in the tray cooks the food. It is popular in East and West Sepik Provinces.

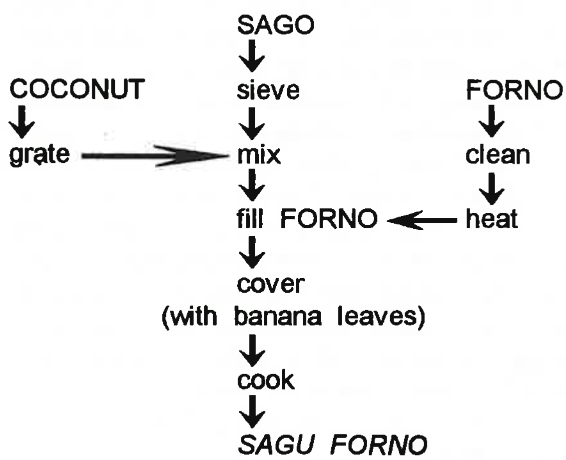
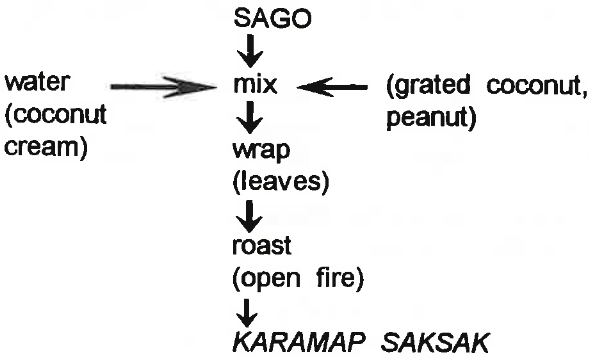


Figure 4. **Preparation of Sagu Forno**

Karamap Saksak

The major raw materials are sago and water or coconut milk (Figure 5) and it figuratively means "wrapped sago". Grated coconut and peanuts may be added. It is usually consumed after the main course and eaten with dry coconut if no grated coconut was added before roasting. It has a short shelf life and is mainly prepared in Madang, Morobe and Sepik Provinces.



Kilikan

This is sago soup with dilute consistency (Figure 6) and is ususally served hot. It is a popular dish in Manus Province.

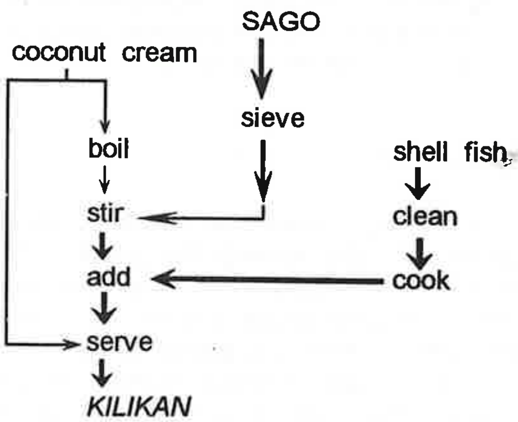


Figure 6. **Preparation of Kilikan**

Mona Sagu

The simplified flow chart is in Figure 7 and is eaten as dessert in the Milne Bay Province.

Sagu Bamboo

This is popular in the Madang Province (Figure 8) and can be eaten with grated coconut.

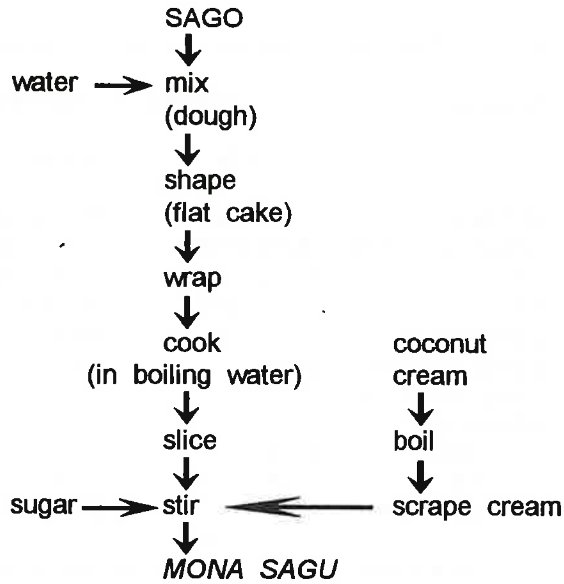


Figure 7. **Preparation of Mona Sagu**

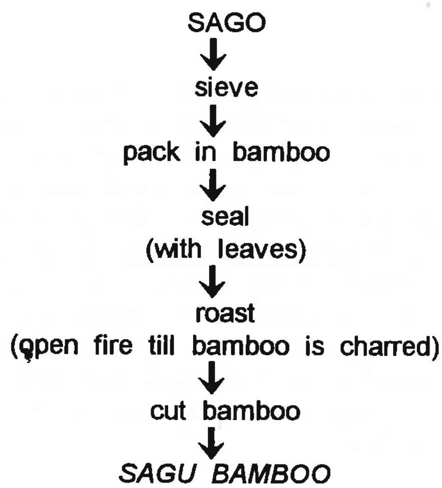


Figure 8. **Preparation of Sagu Bamboo**

STRATEGY FOR UPGRADING

From the above descriptions, it can be observed that sago starch is cooked either dry or wet. Also protein-rich food are traditonally used to increase the nutritional value of the product because sago starch is very low in protein. Using peanut, the protein and energy of the mixtures (Table 1) increased substantially (Sopade & Koyama 1999).

When the mixture was boiled in water and served to tasters in a senory evaluation study, the 30% supplemented mixture was the most desired (Sopade & Koyama 1996). Since peanut is a local product, this observation indicates a possible

Table 1. **Proximate composition of the peanut-supplemented sago samples**

Parameter	‡ Sample: % composition of sago (S) and peanut (P)					
	Peanut	Sago	80S / 20P	70S / 30P	60S / 40P	50S / 50P
Moisture	8.9± 0.53	58.2 ± 0.21	52.1± 0.38	48.4 ± 1.08	37.9 ± 0.34	33.3 ± 0.96
Protein (N x 6.25)	28.3 ± 0.64	0.1± 0.02	8.3 ± 0.76	9.4± 0.86	13.2 ± 1.14	19.1± 0.42
Fat	43.1 ± 1.72	0.2± 0.01	9.5 ± 0.88	10.0 ± 1.31	14.0± 0.74	19.0 ± 2.17
Ash	2.5 ± 0.08	0.2± 0.01	0.8 ± 0.07	1.0 ± 0.09	1.0± 0.11	1.2 ± 0.13
Carbohydrate	17.2	41.3	29.3	31.2	33.9	27.4
Energy (MJ kg^{-1})	24.0	6.9	9.9 (43)†	10.6 (53)	13.2 (90)	15.0 (117)
Energy ratios % contributed:						
Protein	20.0	0.2	14.3	15.2	17.1	21.7
Fat	68.2	1.1	36.6	36.0	40.4	48.2
Carbohydrate	11.8	98.7	49.1	48.8	42.5	30.2

‡ Values are means standard deviations and carbohydrate was obtained by difference.
† Figures in bracket are percent increase relative to the unfortified sample.

Source: Sopade & Koyama (1999).

route for an improved product. However, a major storage concern was the high moisture content of the sago starch, which was obtained from the main market in Lae. The same trend was observed with sago starch bought at markets in Kavieng, Kerema, Lorengau, Madang, and Wewak (Sopade & Kiamur 1999). If the starch is to be stored and used for a reasonable time without the risk of microbilogical and mycological growth, the moisture content must be lower and less than 40%. A form of drying is required and community education is needed on this.

The physico-chemical changes in the sago starch under the various conditions described above in the traditional processing techniques, and in the presence of the diverse ingredeints and concentrations need to be ascertained for quality assurance. The characteristics of sago starch have been summarised by Ito *et al.* (1986), Takahashi (1986) and Gumbira-Sa'id (1994) as;

- easy to gelatinise at 60°C - 82°C,
- easily retrogrades,
- high viscosity,
- easily moulded,
- low syneresis.

From the calorimetric study of Gumbira-Sa'id (1994), it appears that sago starch requires moisture content of not less than 54% for complete gelatinisation although heat induced depolymerisation can occur at lower moisture contents (Sopade 1991). Such a condition, however, requires high temperatures. While gelatinisation aids digestibility, excessive depolymerisation from high temperatures and low moisture contents may cause gastro-intestinal disorders.

CONCLUSION

The various sago-based food decribed indicate the popularity of sago among the people of PNG. There are more traditional food that have not been described or documented and the list is probably inexhaustible. There is a possibility that the same product may have different names in different provinces. This paper, nevertheless, emphasisses the need for a co-ordinated research and information crossflow on sago in PNG. These traditional food need to be identified and prioritised for improvement on a household or community level as a prelude to commercialisation. While conventional sago products could be introduced, there is an enormous potential for tradtional products. Unlike introduced products, traditional products have the great advantage of easy assimilation by the people, who grew up with them.

Although research on sago-based food has been slow to take off, it is hoped that the information contained in this paper will reopen local and international interests in the uses of sago for food in PNG.

Apart from the above, the authors have initiated studies to critically examine different techniques of sago starch extraction in PNG. Presently, there are many sites on the internet devoted to sago palm and it is expected that a country that holds about 44% of the world area of wild sago palm would accumulate useful information on this staple food.

Readers with relevant information on the processing and uses of sago starch in their communities are encouraged to contact the senior author.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the pioneering works of Mr Tony Power presently with Mobil head Office, Port Moresby and of Mr Rashimah New, Formerly of the Appropirate Technology Development Institute, University of Technology, Lae and those who have contributed to the present understanding of processing and uses of sago starch in PNG.

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HORTICULTURE NOTES NO. 35.

A PRELIMINARY GUIDE TO PRODUCE VANILLA IN PAPUA NEW GUINEA

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ABSTRACT

Preliminary information on vanilla production intended for vanilla growers in Papua New Guinea is outlined below. It reports on trails done at Kerevat Lowland Agriculture Experimental Station, Pacific Islands countries where vanilla is grown, and experiences of farmers on the Gazelle Peninsular.

Vanilla is a tropical climbing plant belonging to the Orchidaeceae *family. Two species are of economic importance,* Vanilla planifolia and V. tahitensis. *Vanilla is native to Central America and was introduced to Papua New Guinea and other Pacific Islands during the 19th century. It grows well under moist, humid and shady conditions from sea level to about 600 m altitude. It requires light fariable and well watered soil but not water logged and drained areas. When farming Vanilla, it is advisable to grow on support trees which will also provide shade. Propagation is by cuttings of 80 - 100 cm. Cuttings should be planted at 2.5 m between and within rows depending on spacing of shade trees. Pollination is by hand and to produce commercially viable beans it must be done carefully.*

KEWORDS: *vanilla, vanillin, alternate cash crop, propagation, pollination, curing*

INTRODUCTION

This article is prepared due to a popular demand for information by vanilla growers and people involved with vanilla in Papua New Guinea (PNG). It is important to note here that research is being carried out at the Lowland Agriculture Experimental Station (LAES at Kerevat in the East New Britain Province (ENBP). The information made available here is only preliminary. Some suggestions in this report may change as more information become available. However we believe that information provided here will be useful to farmers and those involved with the crop now, rather than waiting for a full information package which may take a few more years to be released.

Information used here is based on work done by vanilla growing countries of the South Pacific, farmers' experiences on the Gazelle Peninsula in ENBP, past experiences in PNG, and preliminary results of current research by LAES. Relevant literature and experiences have also been consulted.

Vanilla belongs to the *Orchidaceae* family, and grows by climbing on trees. Over 100 species of this genus are reported (Pureglove 1968) but only two are known to be of commerical importance.

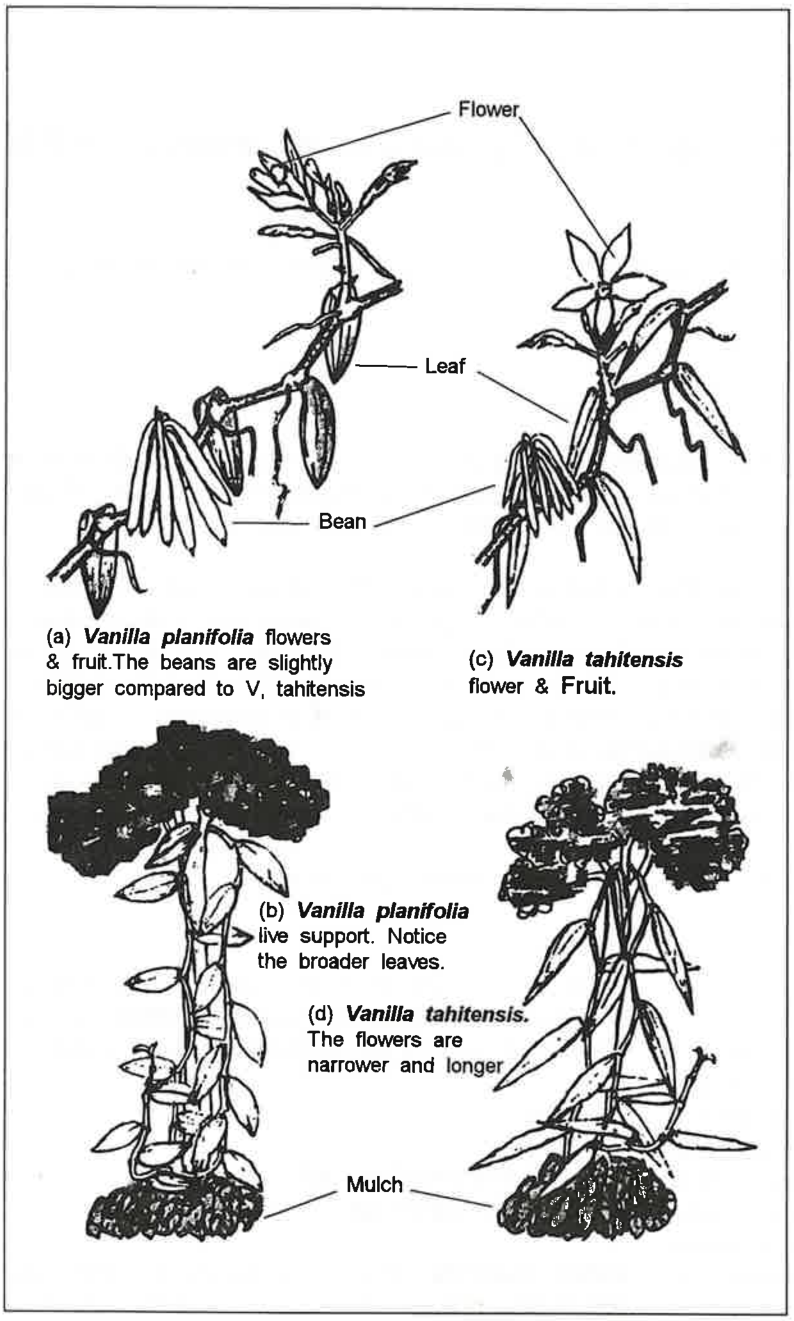
They are:

1. *Vanilla planifolia* (syn. *fragrans*)
2. *Vanilla tahitensis*

Vanilla planifolia and *V. tahitensis* are the most commonly grown of the tree species. A third species, *V. popona* is said to be of commercial importance but it is seldom used.

Vanilla is native to Central America (Mexico and Guatemala). It was traditionaly used for flavouring a beverage drink derived from cocoa beans by the Aztecs of Central America. Today vanilla is used mainly in the food industry. The chemical of importance is vanillin. Cured vanilla beans contain 1-3% vanillin. The extract is then used in flavouring ice cream, chocolate beverages, cakes, custard, puddings and other confectionery.

The two species of vanilla grown in PNG are *V. planifolia* and *V. tahitensis*, where the principal



(a) ***Vanilla planifolia*** flowers & fruit.The beans are slightly bigger compared to V, tahitensis

(c) ***Vanilla tahitensis*** flower & Fruit.

(b) ***Vanilla planifolia*** live support. Notice the broader leaves.

(d) ***Vanilla tahitensis***. The flowers are narrower and longer

Figure 1: **Illustration showing differences between the two vanilla species, *V. planifolia* and *V. Tahitiensis.***

vanilla of commerce is *V. planifolia.* Material of both of these is maintained at LAES. It is easy to tell the difference between the two types when grown together. *Vanilla planifolia* is the more vigorous type, with thicker stem and larger leaves compared to the thiner stem, longer and narrower leaf of *V. tahitensis* (Figure 1).

Vanilla was introduced to PNG some time during the European colonization of the pacific in the 19th century. Other introduced crop species (cocoa, coffee, etc.) have been in the past cultivated on large scale and subsequently gained increasing importance. Vanilla remained only a curiosity and insignificant crop. Except on one plantation on Bougainville (Bym 1984) vanilla was not cultivated commercially until recently.

Compared to other cash crops in the agriculture sector, the vanilla industry is small and insignificant, but is likely to expand. Unfavourable and frequent price fluctuations of major commodity crops and the long fall in the prices of major commodity crops in the recent past has forced us to look at other cash crop possibilities. Vanilla is one of several crops being investigated by LAES to determine its potential as an alternative cash crop. So far, it has shown to have good potential and is quickly becoming a significant minor alternative cash crop. Increasing demand for information on vanilla production and planting material is showing that a small vanilla industry could emerge.

ENVIRONMENT

Vanilla grows best in hot and moist conditions with temperatures ranging from 21°C - 32°C. It grows well from sea level to about 600 meters. A distinction is made later in the paper on the suitablity of different species at different altitudes. An evenly distributed annual rainfall of 2000 mm - 3000 mm is desirable. However a drier period of 3 - 4 months with less rain is essential. This condition checks vegetative growth and induces flowering. Vanilla does not like excessively drained soils nor does it tolerate water logged conditions. It does best on light friable and humid soils. Additional information regarding environment can be obtained from a booklet on how to assess land suitability for vanilla (Venema, 1992) from Department of Agriculture and Livestock (DAL), Land Utilization Section.

Research work at LAES and farmer experience in

PNG is showing that *V. planiforlia* flowers and produces well at elevations above 300 meters and *V. tahitensis* thrives in the coastal areas. It is therefore wise to grow *V. tahitensis* at elevations below 300 meters and *V. planifolia* at elevation between 300 and 600 meters. Because of this it is important to know the altitude of the area you wish to grow vanilla.

PROPAGATION

Vanilla is grown from stem cuttings or vines. Any part of the vine can be used but must be taken from a healthy and vigorous plant. Cuttings ranging from 50 cm to 3 meters have been reported to be used but cuttings measuring 80 cm to 100 cm are preferred. Cuttings less than this will take longer to come into first flowering. Material longer than 100 cm would be seen as wasting material. LAES recommends apical stem cuttings measuring between 80 cm - 100 cm.

SOURCE OF PLANTING MATERIAL

There are several places where planting material can be obtained. Growers have mainly been obtaining their vanilla cuttings from Vunakanau Plantation near Rabaul in the past. There are also several other suppliers on the Gazell Peninsula selling cuttings at the present. Requests are either put directly to suppliers or Alternative Crops Extension and Development Program (ACEDP) Co-ordinator in Kokopo who then co-ordinates the buying and selling. People on the PNG north coast can now obtain their planting material from DAL's ACEDP Co-ordinator in Madang. Material is also now available from Bubia Agriculture Research Station near Lae in the Morobe Province.

LAES has been supplying cuttings and will continue to do so. Prices vary between suppliers and range from K0.50t to K2.00. Material at LAES is selling for K0.50 per cutting.

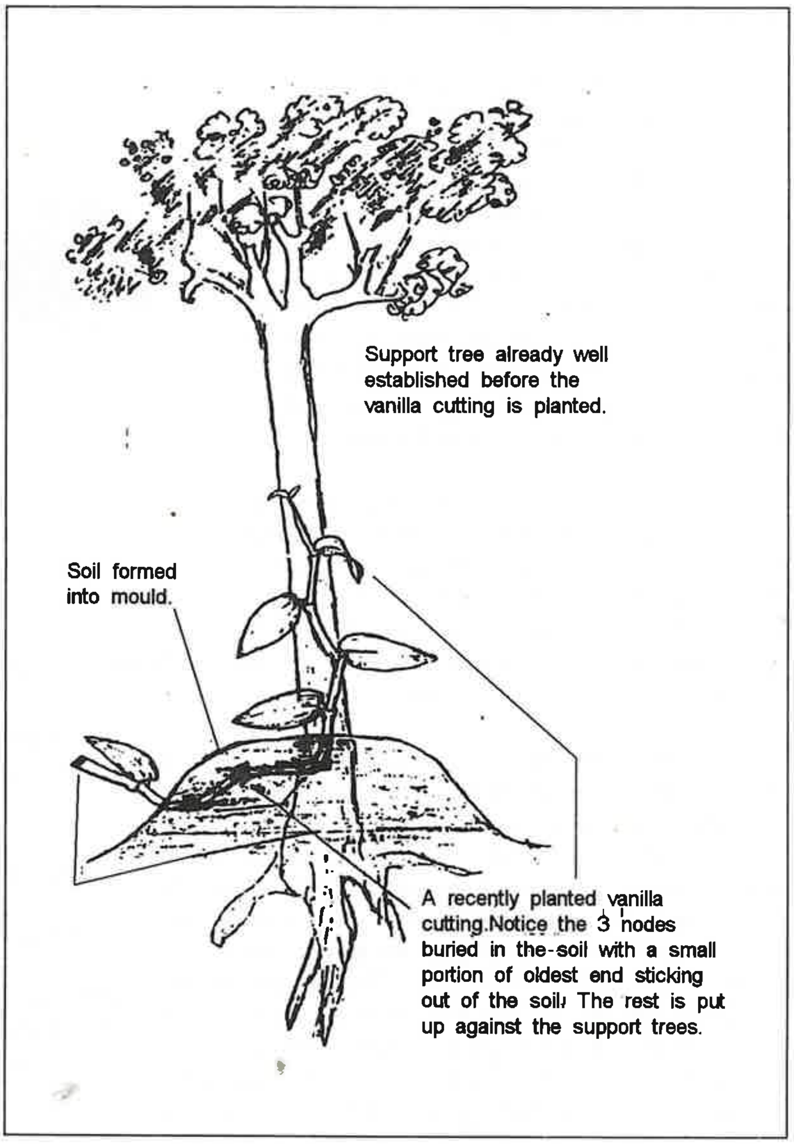


Figure 2: **Planting of a vanilla cutting**

PLANTING

Vanilla cuttings are planted next to the support tree that should have been already planted and well established. A small long hole of up to 10 cm deep and 30 cm long and wide enough to fit the cutting easily must be made. The cutting is then planted as shown in Figure 2.

It is important to plant the cutting with at least two nodes buried in the ground. The end of the older portion of the cutting must be left sticking out of the ground. This will allow for healing of the wound where the material was originally cut. The other half to two thirds of the cutting can be left standing upwards or lying on the ground close to the support tree *(Figure 2).*

SUPPORT AND SHADE FOR VANILLA

Several tree species can be used for either support and/or shade. A good supporting tree must be strong, fast growing, have sufficient branches for hanging vanilla vines on and must not be over shading. It is advisable that the support trees must be planted earlier and allowed to establish well before the cuttings are planted. If ridges or mounds are used, support trees must be planted before their construction. This reduces the risk of it falling over during strong winds or from the weight of the vanilla plant.

Too much light can also be a disadvantage. Vanilla requires a certain amount of shade but this must be reduced when it comes into flowering. Experience at LAES has shown that too much shade does not encourage prolific flowering. Shade must be maintained at about 40% level.

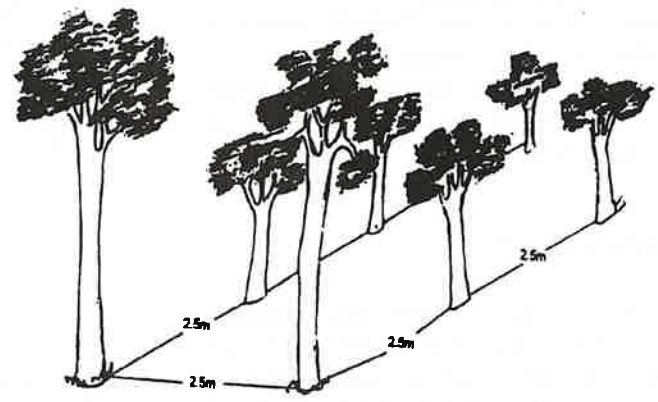


Figure 3. **Spacing of support and shade trees**

Live support for vanilla can simulataneously be used for shade. Two commonly used tree species by vanilla growing countries are *Jatropha cocas* and *Casuarina equisitfolia*. The common Leucaena and Gliricidia were tried at LAES in the the late 1960's and the early 1970's where Leucaena was recommended. The psyllid attack on the Leucaena in the late 1970's and early 1980's devastated Leucaena stands around the country. This meant a new shade / support species had to be identified. LAES is currently evaluating Leucaena *Leucaena diversifolia*, Fiki *Jatropha cocas*, Gliricidia *Gliricidia sepium* and Kalava *Ormocarpum orientale*. Gliricidia has not been sufficiently trialed to be recommended as shade for vanilla. However, many farmers are reported to be using it more than any other species at present, therefore it should be used until a suitable species is identified and recommended.

Farmer experience on the Gazelle Peninsula has shown that Gliricidia planted at 3m x 2m grows well. If spacing of 2.5m x 2.5m is given, the widest spacing experimented with Gliricidia at present, then it must be pruned 4 times a year at 3 months interval. This pruning arrangement should maintain vanilla shade at about 40 - 50% at all time. Other shade tree species being trialed will probably have slightly differenct shade management practices. Farmers are also trailing their own choice of shade and support trees. We do not discourage this as they may find other species suitable for their environment. We would be most interested to know this so we can experiment with the species here at LAES.

SPACING

Spacing varies with the type of shade/support tree species used. Vanilla is being trialed at 2.5 m between and within rows using Gliricidia as shade and support tree. This spacing arrangement gives 1600 plants per hectare (*Figure 3.).*

FLOWERING

Management and environment affect flowering. Under LAES conditions vanilla flowers throughout the year with large monthly fluctuations. Rainfall has a big effect on flowering with peak flowering during the lowest rainfall month of the year. It takes *V. tahitensis* and *V. planifolia* up to 2 and more than 2 years respectively to first flower. This has also been commonly reported by other vanilla growing countries. The earliest first flowering recorded at LAES is 18 and 29 months for *V. tahitensis* and *V. planifolia* respectively.

To induce flowering, up to 10 cm of the vine apex must be plucked or pinched off 6 to 8 months before the flowering season starts in June and continuous through to October.

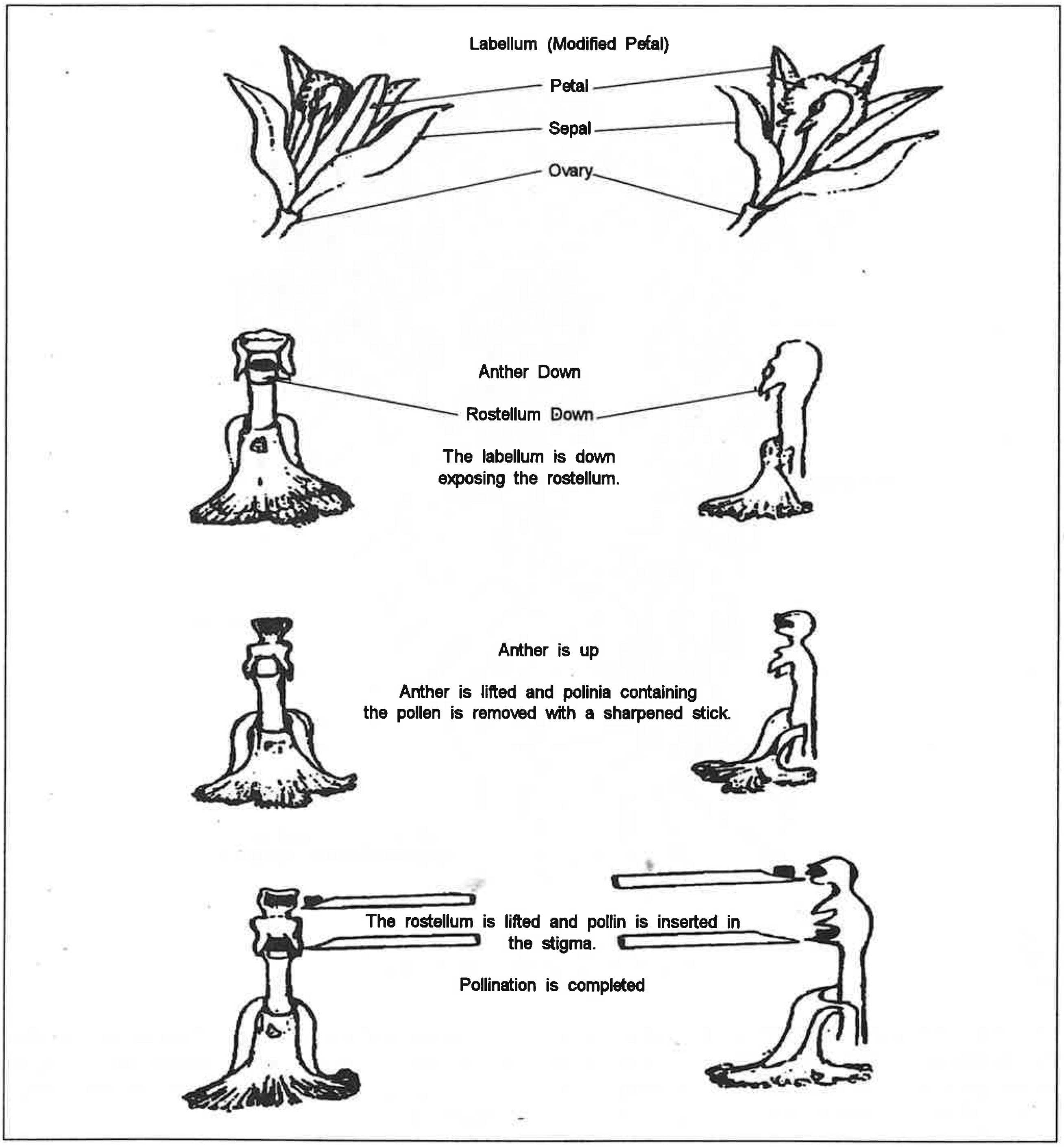


Figure 4: **Vanilla flower and steps leading to complete pollination**

POLINATION

Pollination is a process where a female part of a plant is fertilized by the male part or the pollen in order for it to produce fruits. A single plant may bear many flowers that individually remain open for about 24 hours during which they must be pollinated. Natural pollination of vanilla is very rare. In Mexico the Milipona bee and humming birds are reported to be reponsible for natural pollination (Stace 1961). These bees are not known to be present in PNG.

Pollination in vanilla is very important. The number of beans produced is directly related to how successfully fertilization is carried out. If successful pollination is carried out on 6 of the 10 flowers pollinated then the farmer will only get 6 beans.

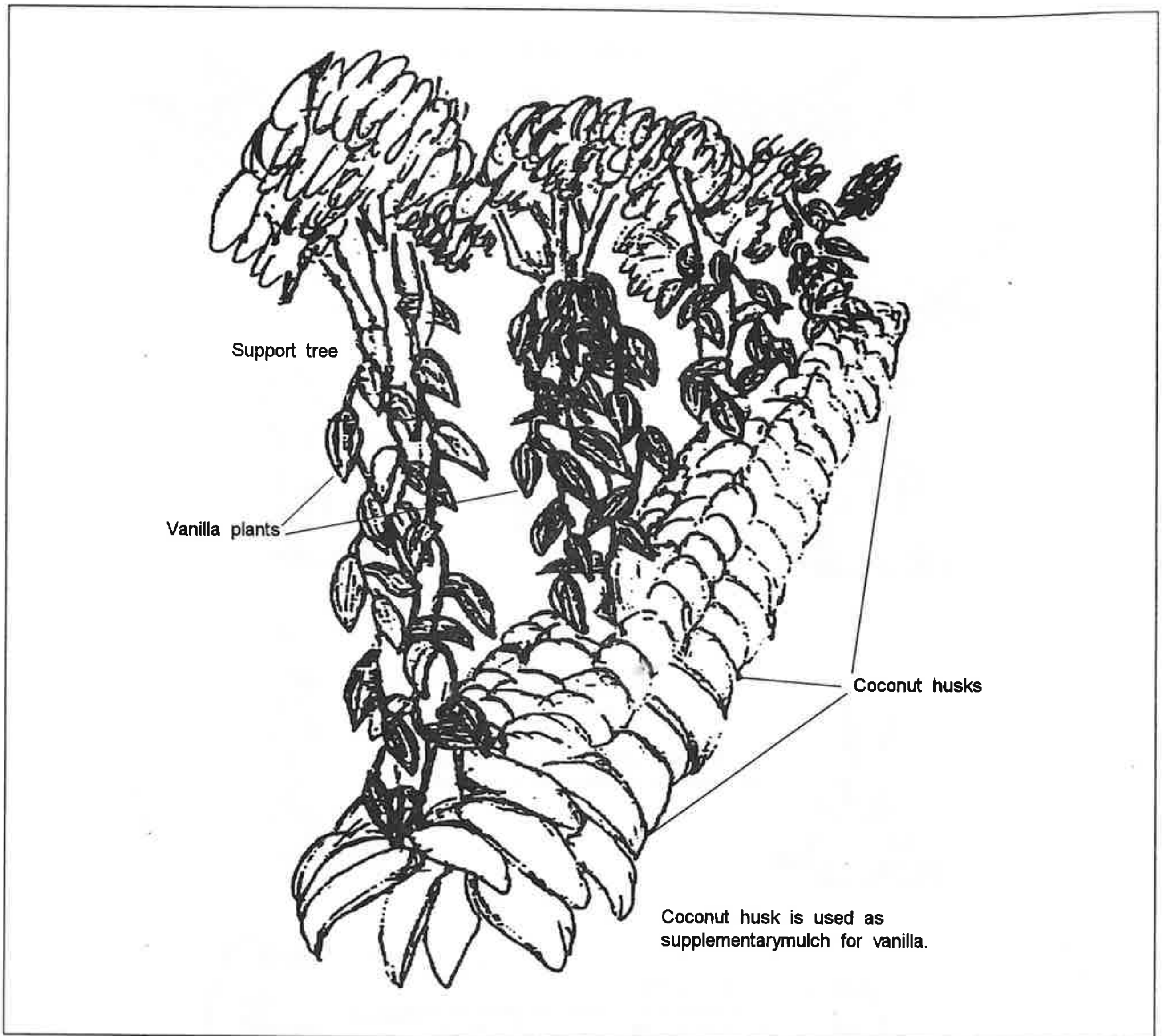


Figure 5: **Mulching of vanilla.**

Therefore it is very important to correctly master the technique of successful polination. All vanilla beans produced for commerical use result from hand pollination. Hand pollination is done using an implement the size of a tooth pick. Usually bamboo splits are used. Reports of natural pollination in PNG is being investigated. An ant seems to be the pollinator (Annon, per. com.). LAES would be most interested in any further reportings of natural pollination of vanilla in PNG.

To pollinate, the flower is held with a thumb and the pointer on one hand and the part holding the male and female parts is pushed down with the fingers on the other hand exposing the cavity containing the pollen (male part). This is pushed upwards with a splinter and the pollen collected. The pollen is then carried carefully on the splinter and deposited on the sticky stigma (female part) on the same flower. Pollination is now done (Figure 4).

If pollination is sucessfully done, the flower will remain intact and slowly dry up with the development of the vanilla bean. If the flowers drop off within a week then successful fertilization has not occured.

WEEDING

While clean weeding of vanilla may not be necessary it is important to control other climbers and weeds. Hand weeding with knives and spades is better then weed control with chemicals. No herbicides should be used as spray drift can adversely affect the plants or even kill them. Most importantly any residual trace will show up in laboratory tests and the vanilla batch being offered for sale will be condemmed by buyers.

HANGING AND LOOPING

Vanilla vines growing upwards from the main support tree trunk and branches must be brought back and twisted around the lower branches of the support tree and hung downwards. When the vine reaches the soil and when there is sufficient length to loop back some of the vines is covered with soil and mulch to encourage new rooting from the nodes. The leaves at the nodes being buried must be removed. The growing point is then placed at the base of the support tree and encouraged to grow upwards.

MULCHING

Mulching has been reported to be very beneficial by most countries. Work at LAES has shown that mulching gave higher yields than unmulched plants (Byren, P.N. 1984; Aburu 1981). Mulching is labour intensive and could be expensive. We will need to look at the effect of long term mulching. However it would be advisable to mulch your vanilla regularly with vegetable matter if the soil is poor. Mulching can be done using material from weeding and pruning from the support/shade trees. Supplementary mulch material like coconut husk *(Figure 5.)* can be used but whatever suitable mulch material available easily can be used. Vanilla mulched using coconut husk at LAES seems to be doing very well at this early stage of our investigation.

PESTS AND DISEASES

Two minor pests could be of economic importance. They are *Hypochlorosis danis milo* GrSm. Syn. *Pseudonotis danisoides* Nicer and *Adoxophyes* spp. These small caterpillers are in the same large group of insects as the butterflies. During their larval stage they damage the young flowers and capsules by chewing on them. Avoid use of insecticide. The numbers are usually too small to warrant any spraying therefore it should be kept in check by their natural predators. Gray weevil has also been seen chewing on the vines. The build up in their population in the vanilla blocks can at times be economically damaging.

Collar rot caused by the fungus *Sclerotium roflsii* is the most important diesease. It affects tender leaves close to the ground level when the vines are looped. This can be reduced by looping to a few centimetre above the ground or onto the coconut husk mulch. A number of infectious virus conditions are potentially important. While a number of strains of virus are reported to be affecting vanilla in Tonga (Pearson and Pone 1988) and other Pacific nations, vanilla in PNG is unaffected. However several plants showing signs typical of viral infection at LAES were destroyed. Samples of the affected plants have been organized for proper diagnosis. The other problem experienced at LAES is caused by root rot fungus, *Phlynus noxius*. The fungus destroys the roots of the support tree causing it to fall over with the whole vanilla plant. If this happens then cut a new stout pole, dip the base in fungicide and plant into a hole as close as possible to the old tree. Stand the old tree next to the newly planted one and tie them together with a soft rope. Use of a copra bag twine would be ideal. Train some of the vanilla vines onto the new pole and the vines will soon take hold of the new support. Do not remove the old support as it will rot and can be used as mulch.

CURING

There is some variation in the procedure used by different curing plants but generally an internationally tested and accepted standard process is used. A number of steps are followed from the time the beans are harvested to when it is packed and marketed as follows:

1. Green bean harvesting and buying

Ripe beans must be harvested from the field on a certain day during the week and brought to the buying points, usually not far from the vanilla blocks. The beans must be bought the same day and brought to a central curing plant.

2. Boiling and sweating

Boil water to 63°C in a 44 gallon drum. Progressively dip all the beans in the warm/hot water for 3 minutes only. Water temperature must be maintained at 60°C - 63°C. After 3 minutes take out the beans and wrap in blankets and put away in sweating boxes for 72 hours.

3. Drying

Sweated vanilla is then subjected to a series of drying processes to reduce moisture content. The beans would normally be sun dried but can also be dried indoors during wet days. Beans are brought out daily, between about 8.00 am and 3.00 pm and spread out on black palatine sheets and allowed to dry. Drying must be done daily for a period of 4 weeks. Turn the beans every two hours to ensure that all beans are equally exposed to the sun. At the same time select the beans which are ready for further in-house drying.

Sun dried beans should be further dried in a spacious and well ventilated house for two weeks

4. Grading and conditioning

It is of prime importance that grading is done by only one person. This person must possess absolute knowledge of what is required.

During drying, identify and select properly dried and good beans for grading. Separate split from unsplit beans. The remaining beans can be moved for further grading.

Vanilla is graded either as marketable or rejected material. A further grading of marketable material is done with A grade material. They are divided into unsplit and split. All low grade and unmarketable material should be disposed.

Each grade is then packed into 200 gram bundles. The bundles are placed into air-tight containers for conditioning. The beans remain in the containers for a period of 5-6 months but exposing them to air for several hours each month. Vanilla aroma develops during conditioning.

5. Packaging and marketing

After conditioning, the beans are prepared for marketing. The cured vanilla is packed in waxed plastic bags to a predetermined weight and put into maturing boxes. It is common to pack one plastic bag to 10kg. Several bags of these are further packed into strong cardboard boxes or into sealed tin boxes for export. The packed material can be stored for up to 1 year while awaiting marketing.

Considerable amount of skill and experience is required to cure the beans to the required marketable standard. Processing for overseas market should be restricted to people who posses correct knowledge in carrying out the curing process properly.

A new curing process is being planned for trial by the authors at LAES. Information will be made available after completing the trail.

TRADE AND MARKETING

Madagasca, Indonesia, the Comoros and the Reunion are at present the biggest producers and exporters of vanilla (Vinning 1992). In the early 1900's Tahiti was the biggest producer and exporter of vanilla. At present Tonga is the biggest producer and exporter from the South Pacific region but the volume produced is only very small compared to the four main producers. PNG has only started growing vanilla in the last couple of years.

Germany, France and USA import about 90% of the world's vanilla. About 50% of this is consumed in the ice cream industry. Export markets for PNG are not yet well established. The few established producers aim for niche markets. Meanwhile samples are being sent to posssible buyers abroad for their acceptability assessment.

The price of natural vanilla fluctuates from year to year like other commodity crops. However it is the most stable of all spice crops with respect to price fluctuations. For example, between 1983 and 1988, price fluctuation on average was 19%; the lowest of all spice crops (Vinning 1992). Over the last year the price of cured vanilla averaged at US$70.00 per kg. Specialist niche market prices are believed to be higher.

Papua New Guinea has very little hard data on marketing so far. At the end of 1992 and the beginning of 1993, cured vanilla was sold at K40.00 per kg for *V. tahitensis* and K68.00 per kg for *V. planifolia* (DAL, ACN 1992).

CAUTION

There is growing interest at present in vanilla but farmers should be cautious. First the supply and demand analysis has shown that the rate of increase in supply is greater than the demand. There is a possibility of over supply leading to a price fall in the near future. The second reason may be associated with social organization and habits of the PNG people. The PNG society based on non-monetary activities may not be favourable for a viable long term vanilla industry.

Vanilla should be encouraged only as an alternative to already existing cash crops. Following points must be taken into account by people involved with vanilla production.

1. **Grow an area you know you can comfortably and economically manage**

Farmers should restrict themselves to growing blocks of 1 hectare and less because it could be quite labour intensive. It is better to have a small very productive block of vanilla than to have a large poorly managed unproductive block.

2. **Obtain correct information**

Obtain correct information from the right people and places on agronomic practices for vanilla. For example, there are two types of vanilla being grown in PNG. One of them grow and flowers well on the coast (up to 300 meters). The other does well at elevations greater than 300 meters. It is important that you grow the right type for your environment.

3. **Curing and marketing**

The quality of vanilla is affected during harvesting and curing. Vanila quality is easily reduced if correct procedures are not followed. It is advisable at this stage to only let people who have the right skills and expertise to be involved in this stage of the process. The survival of a possible PNG vanilla industry rests upon producing only the very best quality.

4. **Market access**

Do not grow vanilla where there are no green bean buyers. Make sure there is an easily accessible local market before you go into vanilla production. If there is none around it is advisable not to grow the crop.

5. **Maintain top quality**

It is vital that the highest standards are maintained at all levels of production. Obtaining information from the proper places will definitely help.

SOURCE OF INFORMATION

People seeking information should contact:

The Team leader
National Agriculture Research Institute
Wet Lowland Islands Program
Post Office Box 204
KOKOPO
East New Britain Province

Telephone: 675 9839145 675 9839200
Fax: 675 9839129

The Program Leader
National Agriculture Research Institute
Wet Lowland Mainland Program
Post Office Box 1639
LAE
Morobe Province

Telephone: 675 4751033
Fax: 675 4751034

The Officer-in-Charge
Stewart Research Station
PNG CCRI
P. O. Box 642
MADANG
Madang Province

Telephone: 675 8521651, 675 8521653
Fax: 675 8521657
Email: srs.ccri@global.net.pg

Also farmers should not hesitate to seek assistance from their local Agriculture Extension Officers'. They should be consulted before seeking help from outside of the farmer's local area.

ACKNOWLEDGEMENTS

We especially thank Mr. Radford who contributed a lot of farmer exprience into this paper. He has also been closely associated with the development of a possible vanilla industry over the last 5 years.

We are also appreciative of PNGCCRI for allowing Nellie Bola to do the scanning of the original drawings and tidying up of the figures. We therefore thank PNGCCRI and Nellie Bola very much for their assistance.

Drawings were produced by Robert Waia

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Note:

We have a pidgin version available for interested farmers not conversant in english.

Mipela igat dispela toksave bilong groim vanilla long tok pisin tu. Sapos yu laik kisim wanpela copi, yu mas raitim pas ikam long:

Distribution Clerk

Publication Section,
Agriculture Information Branch
Department of Agriculture & Livestock,
P.O. Box 417,
KONEDOBU, NCD.

HORTICULTURE NOTES NO. 36

HOW TO MAINTAIN HIGH PRODUCTION OF ASPARAGUS BEANS

LIN GUANG-SHIUNG & ABRAHAM W. SUN. R.O.C (on Taiwan) Agriculture Technical Mission to Papua New Guinea, P.O. Box 4043, Lae, Papua New Guinea

ABSTRACT

Asparagus or Snake beans are a common vegetable grown by many Papua New Guineans. Leaves, tender pods and beans are edible and to increase their yield, new methods of harvesting and prunning are outlined for farmers to adopt.

KEYWORDS: *Asparagus bean, Prunning, Roc Mission*

INTRODUCTION

Asparagus bean (*Vigna sesquipedalis* Fruwirth), commonly known as Snake Bean, in Papua New Guinea (PNG) is a popular vegetable widely grown and accepted by the local people. When growing in small gardens and using traditional methods, the tender pod yields are lower due to the short harvest duration. The R.O.C. (on Taiwan) Agricultural Technical Mission to PNG did an experimental planting at Bubia model farm where the methods of picking tender pods and the need to prune the old flowering axes were demonstrated to some farmers. These management techniques proved that the yield of tender pods can be doubled compared to the traditional methods. The increase in yields was due to the same inflorescence been maintained to give three successful harvests of tender bean pods and the bean plants being encouraged to flower repeatedly. The improved methods are described below.

FRUITING CHARACTERISTICS

Asparagus beans are botanically classified in the legume family. They are indeterminate climbing plants. Staking is necessary to support the climbing as well as to permit good ventilation within the rows of plants. Top-clipping is practiced in field management to encourage development of side branches when the climbing vines reach up to two (2) meters high. The inflorescences occur as racemes at the axil with a long flowering axis where opposite flowers are attached. The oldest flowers are at the base of the inflorescence and the youngest are at the apex. When the first pair of fruits have developed to full length, the second pair is still small, while the third pair exist as flower buds not yet open (Fig. 1, 2 & 3).

PICKING TENDER PODS

PNG farmers generally pick the tender pods by hand. The method is by pulling and twisting the pedicels to detach the pods from the flowering axis. This method is more likely to injure the delicate neighbouring young fruits and flower buds. Once the neighbouring fruits or flower buds are damaged, the number of fruits will be reduced in this inflorescence. The introduced method of picking tender pods at Bubia was by cutting the pods and leaving 0.5 cm of the pedicels with a snub-nosed scissors or sharp knife. It is essential to avoid damage to the neighbouring fruits or flower buds. This method ensure the survival of the succeeding fruit in an inflorescence (Fig 4, 5,6 & 7).

PRUNNING OLD FLOWERING AXIS

After harvesting the tender pods three times from an inflorescence, normally there are no more flower buds occuring and the old flowering axis will die back. The axil leaf buds then start breaking at the node where the old flowering axis is attached. (Figure 8).

In order to encourage early shooting of the axil leaf buds, a technique of pruning the old flowering axes has been introduced and demonstrated by

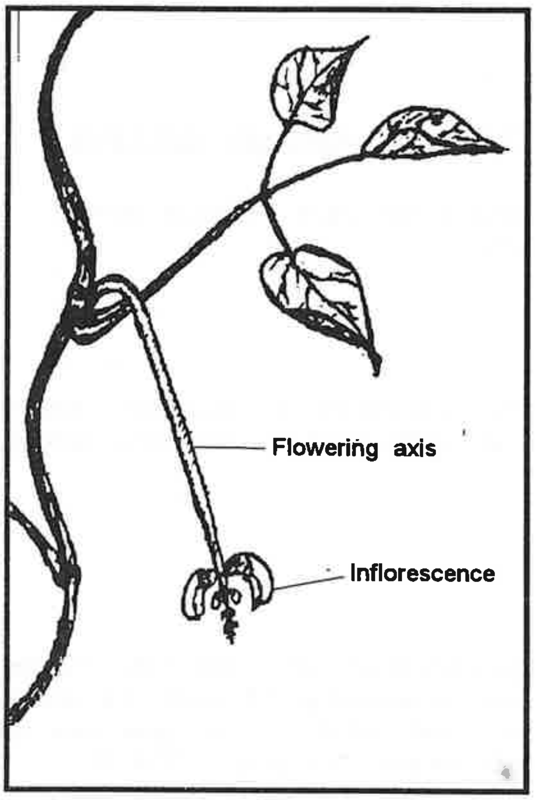

Diagram 1: **Flowers & Inflorescence of *asparagus beans.***

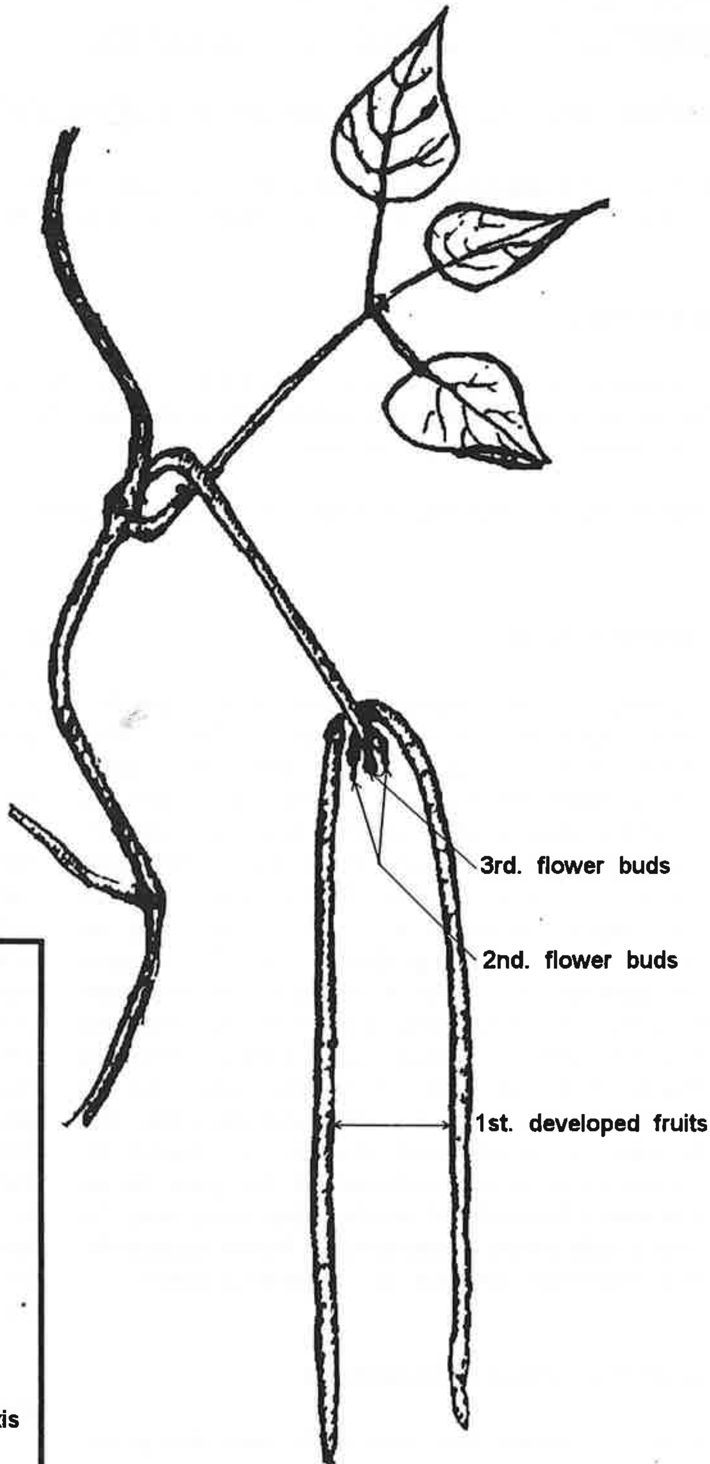

Diagram 2: **Fruiting characteristics of asparagus bean**

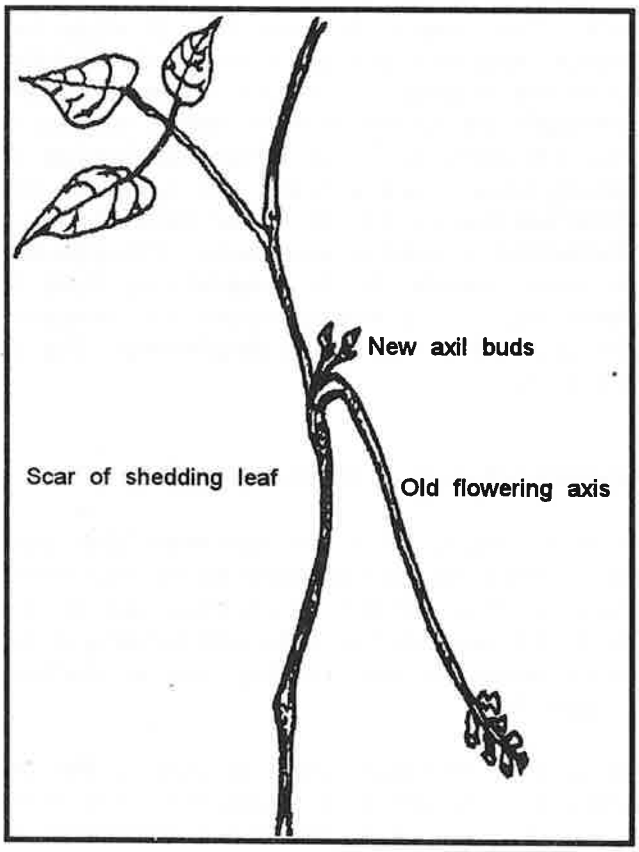

Diagram 3: **The occurrence of axil leaf buds of asparagus bean after the old flowering axis drying back**

Figure 1: First pair of Tender pods fully developed

Figure 1: Cutting the tender pod and remaining 0.5cm to the pedicel with snub-nosed scissors.

Figure 3: The neighbouring flower dubs start breaking after picking the 1st. pair of asparagus bean pods in the same inflorescence

Figure 4: The succeeding flowers in an inflorescence of asparagus bean.

Figure 5: The succeeding fruits in an inflorescence of asparagus.

Figure 6: Cutting the flower axis to 1.0cm to the axil to encourage the axil leaf bud developing.

Figure 7: A new branch and inflorescence have developed start flowering after pruning the old.

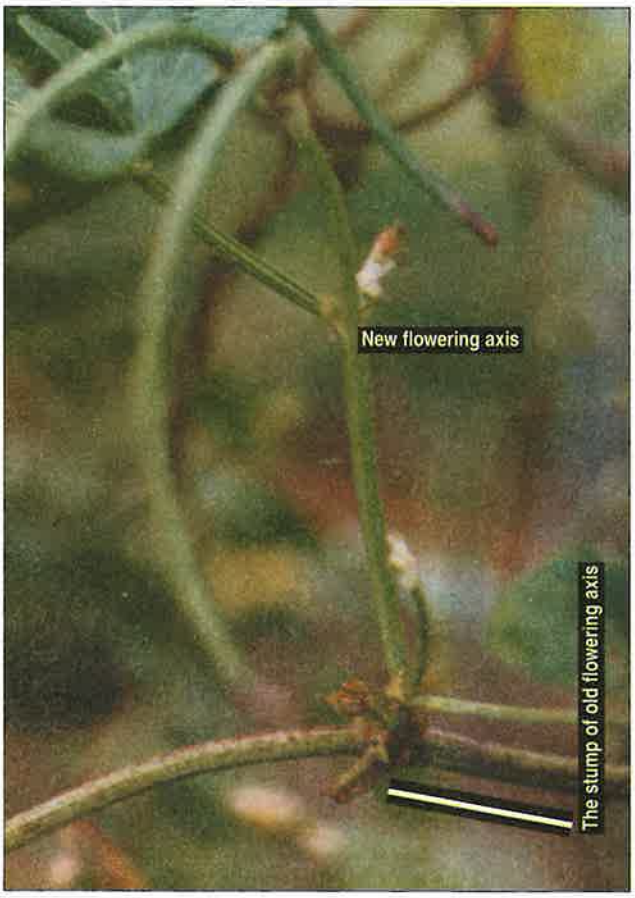

Figure 8: The new fruits have developed after pruning the old flowering axis

the R.O.C. at Bubia. The method of pruning was by cutting the old flower axes to 1 cm to the axil with a snub-nosed scissors or sharp knife after the final harvesting of an inflorescence (Fig. 9). After the old flowering axes has been pruned, the axillary leaf buds start to grow and then develop into new fruit bearing branches. The flowers of the new inflorescence occur after two weeks (Fig. 10 & 11).

CONCLUSION

The traditional method of picking tender pods of asparagus beans is performed by hand but some of the neighbouring buds are injured during the operation. The old methods allows for only two or three pods to be harvested from one inflorescence. In contrast the improved method avoids the damage and save all the neighbouring flower buds. Subsequently this permits six pods to be harvested from one inflorescence, thus increasing the yield.

The other method of increasing the yield was by pruning the old flowering axes to encourage the early shooting of axillary buds. These buds then developed into new fruiting branches and provide tender pods continuously. The harvesting duration is prolonged.

The introduced techniques save all the fruits in one inflorescence and prolong the harvesting duration of individuals plants from 3 months to 6 months. Therefore, the yield increased from 3kg to 6kg per plant.

FURTHER INFORMATION

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Fax: (675) 475 1145

LIVESTOCK DEVELOPMENT NOTES NO. 15.

PRODUCTION AND MANAGEMENT SYSTEMS USED FOR GOATS IN SOME ISLAND COUNTRIES IN THE SOUTH PACIFIC REGION

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ABSTRACT

In the South Pacific region goats are not regarded as traditional animals. However, most countries have selected goat as an animal for consideration. Three systems of production are found; village system, semi-intensive system, and extensive system. The number of animals kept, the peoples' culture and taboo have influenced the production system used in the country. Several constraints attribute to the low goat population and production in the South Pacific region. Amongst these are; low demand for goat meat in most countries except Fiji and Papua New Guinea, the taboo that most island countries population do not like goat meat, that goat is considered as destructive animal therefore requires high fences to enclose them, high loses due to predators like dogs, environmental constraints, and technical, economic and social situation of goat keepers. Goats and other livestock can be integrated with cropping systems and due to their small size, goats could be more suitable than cattle.

KEYWORDS: *goats, production systems, constraints, prospects, South Pacific.*

INTRODUCTION

Goats have been domesticated by nomadic people in the middle east about 10,000 BC (Kettle, *et al.* 1983; Hussain 1988). In the South Pacific region, there is no authentic record of when goats were first introduced. They arrived with missionaries and European settlers in the early 19th century to satisfy their milk demand (ADAB 1979; Amoach 1985), and later by Indian settlers during 1877 - 1916, who introduced meat type goats (Hussan, *et al.* 1983; Hussan 1985). European settlers also introduced goats for fibre in parts of Taveune in Fiji and competed in Australian Agricultural shows and were awarded top prizes as early as 1862 (Hussain 1985).

Goat is an efficient animal and plays a significant role in protein production for humans. They are multipurpose animals producing milk, meat, skins and hair (Devendra 1978). In subsistence agriculture, goats are important due to their unique ability to adapt and maintain themselves in harsh environments. They perform particularly well in areas where the climate is hot and dry. The world goat population is concentrated in the tropical, subtropical areas in developing countries in Africa and Asia, and in warmer temperate regions around the Mediterranean and Central America (Wilkinson and Stark 1987).

The objective of this paper is to highlight the production, management systems used, and potential contributions of goats in Fiji, Solomon Islands, Tonga, Vunuatu, Papua New Guinea (PNG) and Samoa.

SOCIO-ECONOMIC RELEVANCE OF GOATS

In some South Pacific countries goats play an important role in the socio-economic life of people and make significant contributions to the national economy, although in most parts of the South Pacific region goats are not regarded as traditional animals. However, most countries have now selected goat as an animal for consideration (Simpson 1985).

Goats have a low unit value, small size, high reproductive rate, short generation interval, inquisitive feeding habits and high digestive efficiency for coarse forages, and the ability to adapt to variable management systems under different climatic conditions. The above attributes contribute to the acceptance of goat by smallholder farmers in most developing countries of the world. As goats can survive, and even flourish in areas where cattle and sheep cannot because of their digestive efficiency (Aregheore 1996) and low investment input, it has been nicknamed as the "poor man's" cow (Aregheore and Lungu 1997).

At present most countries in the Pacific region import meat. This not only drains the limited foreign exchange reserves but also affect the fragile economy of these countries that depends mainly on foreign aid for development. Goat meat produced locally, apart from being a better quality protein substitute, compared to imported mutton flaps and others would conserve drainage of national foreign exchange reserves.

Countries considered here (Fiji, Solomon Islands, Tonga, Vunuatu, PNG and Samoa) are endowed with good natural and improved pastures, but these resources are not fully utilised at present. Goats can be conveniently raised with food and cash crops and therefore contribute to the diversification of livestock production in these six countries. Other minor socio-economic advantages are; additional income to farmers, job opportunity as well as psychological stability for certain members of the family particularly children, women and the elderly, and also meet the specific family or community social obligations (Aregheore 1994).

DISTRIBUTION AND POPULATION OF GOATS

Small ruminant production contributes substantially to the total productivity in the South Pacific. However, national statistics do not show the exact extent of this contribution and this in turn has contributed to the unreliability of data on goats in the South Pacific. Data on population and distribution of goats in the South Pacific are thus conflicting (Aregheore 1999). Data given by FAO and individual researchers in the region differ significantly.

Available data (Table 1) from different sources (Hussain 1955), MacFarlane 1995, FAO 1986, 1996) attest to the discrepancies in the population figures of goats in the South Pacific. Therefore, there is a need for accurate data on goat populations to enable researchers and policy makers work effectively fully for integration of goats into the farming system of the smallholder farmers.

Table 1. **Goat population in some South Pacific countries**

Country	Hussain 1985	FAO 1986	FAO 1986
Fiji	155,000	185,000	211,000
Tonga	14,000	15,000	15,000
New Calendonia	10,000	-	-
PNG*	3,000	16,000	16,000
Cook Islands	3,000	3,000	7,000
Vanuatu	3,000	11,300	11,300
FSM**	1,100	-	-
Solomon Is.	400	1,200	1,200
Samoa	200	-	-
Tuvalu	100	-	-
Kiribati	100	-	-
Repl. of Palau	80	-	-
Tokelau	16	-	-
Marshall Is.	4	-	-
Niue	-	-	-

* *PNG: Papua New Guinea*
** *FSM: Federated States of Micronesia*

GENERAL PRODUCTION SYSTEMS USED FOR GOATS

There are three systems used for goat rearing in the region (Amoah 1985).

(i) Village system

This system is practised mostly by the subsistence farmers as a part-time operation. About 1-5 heads are generally tethered in situations where crop cultivation is practised. Crop residues and kitchen waste are fed to them. In some situations they are kept close to residences or grazed on rotation near road sides on public land.

(ii) Semi-intensive system

Like the village system, it is also a part-time operation and animals are allowed to graze between 4-6 hours in a day. This grazing could be in the morning or evening under coconut or oil palm plantations. Stocking rate under this system may range from 16-40 goats per hectare and this depends on the type of herbage available. They may be fenced in paddocks as practised in Fiji and in Samoa. The goats under this system may be housed or given some forage or crop residues as supplement. By-products like copra meal and brewers dried grains may be fed occasionally during critical periods. Number of goats may range from 10 on private farms to over 500 on government owned farms.

(iii) **Extensive system**

Under this system goats range freely and mostly unattended. Stocking rate ranges from 1-4 goats /hectare. Management is almost zero with very little inputs. Goats under this system also graze under coconut during the day and are confined at night. Extensive system is practised in Yasdawas Lomaiviti, Lau, in Fiji and, Ha apai and Vava'u group of Islands in Tonga.

With the exceptions of Fiji, Tonga and Samoa where goats are raised under the above system in government farms and research stations, animals are usually confined and grown as meat and milk producers in various countries.

PRODUCTION SYSTEMS USED IN DIFFERENT COUNTRIES

The goat seem to have outlived its rather misplaced bad reputation as an unwanted destroyer of the terrain, as humans become more aware of its importance as a cheap source of meat and other products, relative to other ruminants, when properly managed (Amoah 1985). Due to their rumen physiological adaptation goats can live on a wide range of locations and feed Aregheore 1996). Therefore, this adaptation has made goats survive in the South Pacific.

The peoples' culture and taboo and the number of animals kept have influence on the production system used in a country. Below is an account of production and management systems used for goats in Fiji, Solomon Islands, Tonga, Vanuatu and Samoa.

Fiji

There is no uniform single system of goat management practised in Fiji (Walken-Brown 1984). Vast majority of goats are kept as a subsidiary enterprise, and because of competing demands for time and other reasons, most farmers use very low or zero management systems. However, most goat farming systems fall into one of the following size categories, (Walken-Brown 1984).

Small scale goat raising is a side line to sugarcane and other cash crops. This systems is practised, effectively by Indian farmers. Most of the country's goat population is reared by subsistence and small scale farmers. The goats are kept mostly for personal use with occasional sales. They are usually tethered at roadsides (embankments) or on uncropped land by day, and shelterd and protected at night. However, goats in Yasawas Lomaivily, Lau in Fiji range freely unattended. Fijian cattle farmers at the Western Division, particularly in the Beef schemes such as Yalavou, Ului Saivou and Tilivalevu also raise goats. They graze goats extensively on native and semi-improved pastures under goat fencing with provision for shelter but with few other management inputs or supervision.

Goats raised by Fijian landowners on offshore islands particularly in the Yasawas range freely apart from occasional night yarding and slashing of *Leucaena leuocephala* for supplementing feeding. Large scale goat raising by coconut plantation owners in Vanua Levu, Taveuni and Laucala maintain clean plantations to facilitate nut collection.

Goats are also reared, mainly by Indian farmers, as a sideline to dairy farming in the Central Division. Presently there are some 450 or more supervised commercial goat farms in Fiji where management input in the areas of nutrition, breeding, health and stock control are promoted and in most cases adopted. These farms are scattered all over Fiji with a higher concentration in the Western Division.

Solomon Islands

Goats are not traditional animals to most people in the Solomon Islands. They are found throughout the island, and mostly on government farms and those held by missions and schools (Baker and Polke 1985).

In the government and commercial farms, goats are well managed. The aim of the government farms is to breed and distribute goats to smallholder farmers. On government and smallholder farms, grazing is mainly in the day on pastures. Main pasture species grazed are para grass (*Brachiara mutica*) and centro (*Centrosema pubescens*) but are varied in quality and quantity.

Goats grazing is also done under coconuts to control weed to facilitate nut collection similar to one of the systems in Fiji. Grazing cattle and goats assist in weed control for better pasture usage. Under smallholder production systems goats are generally tethered on native pasture.

Tonga

There are about 15,000 goats in Tonga (Moala 1985). About 85% of the goats are tethered, while in Haapai and Vavau group of islands goats range freely. Village and extensive production system is used and goats are kept mainly for meat purposes. Only a small sector of the population has access to goats, however, there is a good potential for development.

Anglo-Nubian crossbreeds are predominant in the country, but there are also some indigenous goats in the outer islands. Herd ownership range from one to fifty goats as a side line operation to crop production.

Vanuatu

There are about 11,300 goats in Vanuatu and the national consumption of goat meat and milk is low. Over the years there have been no major changes in goat production. Managing goat flocks is often less viable as people have aversion in Vanuatu to eating billies. Majority of goats are found in the villages and others on commercial farms.

Village production systems predominate in Vanuatu and most goats are found in the Tafea region (36%), followed by Eppi (20%), Pentecost (17%), Shepherds (15%) and Santo/Malo (12%). Interest in developing goat production has been expressed by most farmers.

Papua New Guinea

The population of goats is large compared to sheep in PNG and the highest concentration is in the Simbu Province. There is much demand for goats in villages in the Highlands and Island Provinces. However, there are no distribution centres where goats can be obtained. Village and extensive systems are practised in PNG. However, the government has for sometime taken some measures to promote goat production and also aim at improving native breeds through crossbreeding and subsequent distribution to farmers.

Samoa

Goat population in Samoa is small and until recently only one farmer kept goats in Samoa. But recently the University of the South Pacific, School of Agriculture, Alafua Campus has taken the initiative to promote goat production using Anglo-Nubian crossbreeds. The School of Agriculture at present has set to study goats suitability, demand on the environment and social system in Samoa. This start was based on the report of Low (1981), on earlier goat pilot project of USP, SOA in the late 1970s to early 1980s which then influenced a number of individuals in Samoa to start goat farming with small herds. The school also intends to create awareness for the importance of goat production in the country.

A semi-intensive system of production is practised by the sole goat farmer in Samoa. In this system goats graze freely on pasutre under coconut trees during the day and are housed at night in a raised shed and household wastes and crop residues when available are given as supplements in the evenings. However, in the School of Agriculture farm, the goats are confined and all modern day management practices such as feeding, routine and health management are observed.

CONSTRAINTS AND PROPECTS OF GOAT PRODUCTION IN THE REGION

Several factors contribute to the low population and level of production of goats in the South Pacific (Gall and Huhn 1981, Hussain 1985, Baker and Polke 1985, Aregheore and Lungu 1997). These include; current low demand for goat meat in all countries except Fiji and PNG; the taboo that some Island countries' population do not like goat meat; that goat is considered as destructive therefore requires high fence to enclose them; high incidence of losses due to predators like dogs and pigs; the prevailing hot and humid climate in the islands favours gastrointestnal parasites, mainly roundworms and tape worms which affect their health and affects their performance. Others are lack of technical and management skills and poor stock management practices responsible for poor performance of goats. These include lack of access by farmers to credit despite their interest in goat farming therefore production remains at subsistence level, and the social status of goat keepers.

Goats is regarded as the poor man's cow (Aregheore and Lungu 1997), therefore its low level of acceptance poses as an essential obstacle for all measures in its production. It has been observed that the position in the social hierarchy of people keeping goats in many countries are considered as low and that goats are considered a necessary evil, and there is a danger that development will not extend over a long period of time (Gall & Huhn 1981).

However, goats and other livestock can be conveniently integrated into cropping systems. Due to the small size of smallholder farms, goat is more suitable than cattle. Goat farming will contribute to the diversification of livestock production in the South Pacific region. Farmers with large cattle herd and paddocks can mix goats and cattle for grazing. It has been observed that grazing spectrum of the goat is used. While cattle and sheep prefer grasses and eat almost exclusively these if available, goats browse on any herbs and grasses. (Aregheore & Ikhatua 1997).

Goat meat is a rare commodity and its availability determines its level of consumption in most situations. The high demand for live goats during festival times is a promising indicator of their acceptance as a source of meat (Hussain 1985). Goat milk is highly priced in some communities and is claimed to have dietetic properties, and these properties are said to stem from its better digestibility due to smaller fat globules and a finer texture of the curdled case in as well as antigenic properties which differ from those of cow's milk (Gall, *et al.* 1981). Hide and skin of goats are export commodities which the small island countries can exploit as a foreign exchange earner.

On account of their low unit value, small size, high reproduction rate, short generation interval, inquisitive feeding habits and high digestive efficiency for coarse forages combined with their ability to adapt to variable management systems under different climatic conditions, goats should be encouraged and reared as animal of choice in the South Pacific countries.

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RESPONSE OF SOME SPECIES OF *AESCHYNOMENE* TO APPLICATION OF PHOSPHORUS IN EASTERN HIGHLANDS PROVINCE, PAPUA NEW GUINEA

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ABSTRACT

A glasshouse experiment was conducted at Menifo Sheep Research Centre (1405 m a.s.l.) for a period of 28 weeks commencing in July 1996 to determine the responses of two cultivars of Aeschynomene americana, *cv. Lee and cv. Glen, and two other species,* A. villosa *(CPI 93621) and* A. brasilliana *(CPI 92519) to application of phosphorus. Both fertiliser treatments and genotypic differences had an effect on leaf dry-matter yield. Application of phosphorus significantly improved (P<0.01) the relative leaf dry-matter yield by 32-47% and A. villosa (S3) produced a significantly higher (P<0.05) leaf dry matter yield. There was no effect of phosphorus on stem dry-matter yield but between genotypes,* A. americana, *cv. Lee and* A. villosa *had significantly higher (P<0.05) stem dry matter yield. Phosphorus had a significant effect (P<0.05) on root growth. Phosphorus also significantly improved (P<0.05) relative dry-matter yield in all genotypes by 40.52%. Leaf/stem and shoot/root ratios were not sensitive to application of phosphorus.* A. brasilliana *had a significantly high (P<0.05) leaf/stem ratio compared to* A. americana, *cv. Lee, cv. Glen and* A. villosa. *Conversely* A. villosa *had a significantly higher (P<0.001) shoot/root ratio followed by* A. americana, *cv. Lee while difference between* A. americana *cv. Glen and* A. brasilliana *was small. In terms of forage quality,* A. brasilliana *was more efficient on these soils. This study showed that phosphorus efficient species are valuable in reducing fertiliser requirements and can improve the returns obtained from application of moderate fertiliser.*

KEYWORDS: *Aeschynomene,* Soils, Eastern Highlands, Phosphorus.

INTRODUCTION

Most soils in the highlands are inherently low in available phosphorus (P) for legume growth (Sivasupiramanian *et al.* 1986). Increasing grazing pressure and stocking rates due to economic and social pressure further aggravates this. To alleviate this deficiency, application of P fertilisers is a standard practise. However the high cost and the amount of fertiliser required to increase the availability for legume growth (Parfitt & Mavo 1983), prevents the use of fertilisers and as a consequence, P deficiency in pastures is becoming evident. Various cost efficient options are available particularly for soils low in available P. This includes amongst others, the use of species and cultivars that are P efficient.

This experiment examines the effect of phosphorus on the growth of *Aeschynomene* species and accessions which are known to tolerate poor conditions. As genetic diversity exists both within and between species (Bishop and Hilder 1993), this offers the opportunity for exploitation to suit soils low in available P.

MATERIALS AND METHODS

A glasshouse experiment was conducted at Menifo Sheep Research Centre (1405 m a.s.l.) for a period of 28 weeks, commencing in July 1996 to determine the response of *Aeschynomene* species to application of P.

The soils were collected from a semi-commercial sheep farm in Napamogona near Goroka which represent one agro-ecological zone for sheep farming in the Eastern Highlands Province. Soil samples were taken from an area that was previously grazed with sheep and cattle, and during the time when corn (*Zea mays*) was planted. No inorganic fertilisers were used in the area. The samples were taken at random to a depth of 30 cm, bulked and a composite sample air-dried. The chemical status of the soil is given in Table 1. The air-dried soil was sieved through a 5 mm screen to remove plant materials and a sub-sample collected for potting. The pots had a surface area of 165.05 cm^2 and were filled with 1.0 kg of air-dried soil and well consolidated. Plastic lining was used inside the pots to avoid leaching.

Table 1. **Chemical analysis of soils from Napamogona, Eastern Highlands Province, Papua New Guinea**

Soil property	Method of determination	Value
pH	1:2.5 soil:distilled water	6.1
Extractable bases me. 100g	Ammonium acetate	
Ca		12.6
Mg		4.96
K		0.56
Na		0.03
Cation exchange capacity	Kcl extraction	23.9
Base saturation %		76
P mg/kg	Olsen extraction	6
Organic Carbon %	Walkey and Black	23
Total N %	Kjeldahl	0.19
C/N ratio	Walkey and Black	12

Treatment seeds were scarified and germinated in sacks and transferred to pots. After sixteen days, the fully emerged seedlings were trimmed to 3 plants per pot and materials left on the soil surface. All pots were watered daily to maintain moisture content at field capacity and weeds checked and left in the respective pots. After 28 weeks, all the plants were harvested and separated into leaf and edible stems (6 mm in diameter), stem and root (including nodules) fractions. The components were then dried in an air forced draught oven at 70°C for 48 hours to determine dry-matter yield (DMY).

The experimental design was a randomised block in a split plot arrangement with three replicates. The main plots were five levels of P. P as 19.9% $NaH_2PO_42H_2O$ was applied at rates equivalent to 0 (PO), 20(P20), 70 (P70) and 120 (P120) kg/ha of P on a surface area basis. The sub-plots were two cultivars of *Aeschynomene americana* cv. Lee (S1) and cv. Glen (S2), and one accession each of *A. villosa* CPI 93621 (S3) and *A. brasiliana* CPI 92519 (S4). All yield data was subjected to an analysis of variance and differences between means were tested for significance using the *t*-test.

RESULTS

As the analysis of variance (Table 2) showed no interaction between different genotypes and rates of P application, the results are presented as main effects only. Both fertiliser treatments and genotypic differences had an effect on leaf DMY. Application of P fertiliser significantly ($P<0.01$) improved relative leaf DMY by 32-47%, however the differences between the added rates were not significant. The correlation between increasing P rates and leaf DMY was significant (r^2-=0.81, $P<0.05$) (Table 3). S3 produced significantly ($P<0.01$) higher leaf DMY relative to S1, S2 and S4. There was no effect of P on stem DMY (Table 3), however between genotypes, S3 had significantly higher ($P<0.01$) stem DMY compared to S1, S2 and S4 (Table 4).

P had a significant effect ($P<0.01$) on root growth of all genotypes. Maximum root growth was achieved at 50 kg/ha (Table 5) and the correlation between P rates and root growth was not significant ($r^2=0.33$, $P<0.05$). The response of total DMY was similar to that of the leaves. Application of P also significantly improved ($P<0.5$) relative total DMY in all genotypes by 40-52% (Table 5) but the correlation between increasing P levels and total DMY was not significant ($r^2=0.53$, $P<0.05$).

The relative increase in leaf DMY was greater than the roots and leaf DMY continued to increase with increasing levels of P above the level at which there was no increase in root DMY. When the other growth indices were considered, leaf/stem

Table 2. **Summary results of analysis of Variance on dry-matter yield (g/pot) of different components.**

Source of Variation	df	Mean square values of yield components					Total
		Leaves	Stems	Roots	Leaf/Stem	Shoot/Root	
Phosphate level (P)	4	0.76**	0.68	1.77**	0.40	1.07	4.51*
Main plot error	8	0.06	0.10	0.16	0.18	0.37	0.82
Species (S)	3	0.41**	0.58**	0.26	0.65**	10.48**	0.74
P x S	12	0.09	0.06	0.11	0.18	0.45	0.40
Sub-plot error	30	0.07	0.11	0.17	0.21	0.64	0.69

*P<0.05, **P<0.01

Table 3. **Effect of Phosphorus on leaf dry-matter yields (g/pot) of four different *Aeschynomene* genotypes**

Phosphate levels	Species				
	S1	S2	S3	S4	Mean
PO	0.49	0.69	1.10	0.88	0.77
P20	1.39	1.01	1.24	1.03	1.17
P50	1.18	1.06	1.19	1.12	1.14
P70	1.20	1.11	1.55	1.24	1.28
P120	1.53	1.01	1.89	1.38	1.46
Mean	1.16	0.98	1.38	1.13	

LSD to compare S means at 5% - 0.20, LSD to compare S means at 1% - 0.27
LSD to compare P means at 5% - 0.23, LSD to compare P means at 1% - 0.34

Table 4. **Mean dry-matter yield (g/pot) of plant components of four different *Aeschynomene* genotypes**

Species	Plant components		
	Stem	Leaf/Stem	Shoot/Root
S1	0.88	1.55	2.89
S2	0.67	1.70	1.70
S3	1.04	1.42	3.65
S4	0.62	1.94	2.27
Lsd 5%	0.25	0.34	0.60
1%	0.33	0.46	0.80

Table 5. **Effect of phosphorus on root and total dry-matter yield (g/pot) of *Aeschynomene* genotypes**

Phosphate levels	Plant components	
	Roots	Total
PO	0.50	1.72
P20	0.86	2.89
P50	1.06	2.91
P70	0.84	3.05
P120	1.00	3.56
Lsd 5%	0.38	0.85
1%	1.24	1.24

and shoot/root ratios were not sensitive to application of P. S4 had a significantly high ($P<0.05$) leaf/stem ratio compared to S1, S2 and S3 (Table 4) and conversely, S3 had a significantly higher ($P<0.01$) shoot/root ratio followed by S1 whilst any difference between S2 and S4 was small (Table 4).

DISCUSSION

Despite the high base saturation and exchange capacity (Table 1), P unfortunately reacts rapidly with soil constituents to produce relatively insoluble P compounds resulting in its low availability in soil solution for plant growth. Under this condition, the extent of response by the genotypes to application of P was depended on the requirements of different plant components and their efficiency to utilize P.

The high correlation between increasing P levels and leaf DMY observed here demonstrates that P has a greater effect than N, K and S in stimulating early growth of seedlings (Whiteman 1977). This can be explained on the basis of increase in leaf growth rates as a subsequent effect of P on rapid development and growth of nodules and increase in assimilation of N by the whole plant (Gates 1974), and translocation of assimilates to the tops. This is evident in the continued increase in leaf yield relative to root yield. As genetic diversity exists between species (Bishop and Hilder 1993), the genotypes are at variance in their ability to take up and utilise P rather than to differences in internal requirements (Stem 1984). S3 produced more leaves and stems, however in terms of fodder quality, S4 appear to be more efficient in these soils as demonstrated by high leaf/stem ratio followed by S2, S1 and S3 respectively. S1 and S3 had a high propotion of stems and lower root growth compared to S2 and S4 which had a higher root growth relative to shoot growth. The high root growth in S2 and S4 demonstrates their ability to explore a volume of soil to recover P which tends to diffuse over very short distances (Lewis and Quirk 1967) and this may have enhance their efficiency of utilisation under such circumstances. Other responses of herbaceous legumes such as *Stylosanthes humilis* (Andrew 1996) and *Stylosanthes guianensis* cv. Endeavour (Chantkam 1978) have shown that species differ in their ability to absorb P at low solution concentration. The linear increase in root growth at the lower P rate (20 kg/ha) may be explained on the basis of inherently low P status and a critical root concentration was reached at 50 kg/ha as indicated by the curvilinear response. Beyond that, luxury consumption of P in roots inhibited cation absortion. Legumes which are adapted to low fertility conditions such as *Stylosanthese* species and *Trifolium subterraneum* are known to be susceptible to high P rates (Rossiter 1955, Asher and Loneragan 1967). These species however have special attributes that enabled them to perform best under different environments (Bishop and Hilder 1993).

Application of P fertilisers improved the total DMY of the genotypes, however, the response due to P was marginal (69%). Variation due to genotype accounted for only 31%, which implies that despite a lack of significant correlation, the introduction of suitable genotypes cannot substitute for the effect of fertiliser at the level of P input. The lack of any significant differences between added P rates suggests that either the genotypes were susceptible to high P rates or that the initial P requirements of these genotypes were just above maintenance (Winks 1973, Shaw and Andrew 1979) and can be achieved at a minimum rate of 20 kg/ha. The two latter attributes are adaptive features of nutrient efficient species. Similar responses were observed with *A. facalta* which persisted on poor sandy soils and responded to moderate application of superphosphate (Dicker and Garden 1985). These attributes may also explain the lack of interaction on all measured variables. P concentration in the leaves were however not determined to verify if such low P tolerant species contain sufficient P in the edible portions to sustain growth performance of grazing animals.

The native pastures in the highlands are generally low in N and P and this has become the focus of pasture improvement. The effect of P fertiliser for increasing pasture growth and also to improve forage concentration of essential elements to satisfactory levels for adequate growth performance of grazing animals is becoming more important. This study demonstrated that P efficient species in terms of P required/quantity of DM produced are valuable in reducing fertiliser requirements and can improve the returns obtained from application of moderate fertiliser. In terms of forage quality, S4 is more efficient on these soils. However caution should be exercised here as low yielding genotypes also have other desirable characteristics such as persistence (Bishop and Hilder 1993) and their suitability will be determined under a cutting regime to simulate the effects of grazing.

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VOLUMES 11-20, 1985 - 1999

by
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with assistance from Betty Aiga & Jones Hiaso

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