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CONTENTS

Editor: Catherine Kilroy Cover: Jackson Kaumana

WRITE AN ARTICLE FOR HARVEST

Harvest has articles on all aspects of primary industry including agriculture, fisheries, forestry and livestock. It is read by researchers, extension workers, students and teachers all over Papua New Guinea and overseas.

Because of this, HARVEST articles help to keep everyone in touch with new developments in primary industry in Papua New Guinea.

This means that writing an article for HARVEST is a very good way of letting people know about your work and about the primary industries of your area.

There is more information on how to write for HARVEST at the end of this issue. If you have any problems about writing an article then the HARVEST editor will be pleased to help.

Readers' comments on articles in HARVEST or on the magazine in general are welcomed. Please address any letters to the Editor, HARVEST, Publications Section, D.P.I., P.O. Box 417, Konedobu.

LEARNING FOR EXTENSION

By D.J. Underwood, Principal Extension Officer,
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WHAT IS EXTENSION?

"Extension is education in real-life situations".

Agricultural Extension, then, is basically concerned with informal out-of-school training for the farmer and his family.

The aim of this out-of-school training is to extend agricultural productivity for both subsistence and cash farming in order to improve the quality of life in rural areas.

A major problem we all have is the change and uncertainty all around us. As extension workers it is our responsibility to look at the changes and uncertainties in agriculture as they affect the rural people.

Think of the changes that take place when cash crops are introduced to a subsistence farming system. There are changes in work patterns and in the distribution of labour for both men and women. The patterns of trade and exchange are broadened as a range of new goods and services find their way into the society. A new source of food leads to changes in diet together with changes in the system of family food supply. All of these changes have uncertain outcomes. That is, no-one knows all about the ways the changes can affect people's lives.

The ability to manage changes like these is clearly an important goal for education.

The education that we are talking about is the helping of people to:

a) identify their own problems and opportunities.

b) use new information to achieve improved benefits through solving problems or grasping opportunities.

For example, to the Highland farmers of Papua New Guinea, preparing land for a garden with the use of hands and sharpened sticks was no problem - until steel tools were available. After the tools were available gardening without the use of a steel spade then seemed to be a real problem. The people then looked for information on how to overcome this new problem. The result was that as the supply of steel tools increased, all farmers grasped the opportunity to benefit from the change.

A highlands woman uses a traditional digging stick to plant her kaukau. Most people have now switched to using steel spades as they are much more efficient - an example of how people can adapt to and benefit from change.

Now let us move from the general idea of "education" to the particular idea of "learning."

LEARNING FOR EXTENSION WORK

In order to manage change and uncertainty both the extension worker and the farm family need to be effective learners. Learning for the sake of learning, as we do at school, often does not really help in real-life situations. With the learning described in this article, decisions can be made towards the improvement of real-life situations. This goes on throughout life. It is life-long learning.

The following are a few points to take note of when thinking about education as life-long learning:

1. Learning is a process that goes on throughout life. Each individual is responsible for the amount of learning he or she does.

2. Individual learners

   a) should be encouraged to take up the responsibility to learn for their own needs;

   b) have different needs and goals;

   c) differ in the way they improve their own abilities to learn knowledge and skills, and develop attitudes and beliefs;

   d) differ in the speed at which they learn;

   e) learn more effectively when following their own objectives rather than objectives set by others.

3. Having clear objectives makes it much easier to achieve results, and to measure progress.

4. Learning is more effective when the learners are actively involved in learning experiences rather than just listening and watching facts being taught or skills demonstrated.

The aim of extension work is to help farmers become more effective at managing real-life change in the environment around them. But in order to help others we must first be effective learners ourselves.

Look at the situation of an agricultural extension officer when he arrives at a new posting. He already has some training which qualifies him for the position; and he also has some experience in agriculture and in extension. However, he is facing many changes which he will need to manage so that he can adapt to his new situation. He obviously has a lot to learn - about different customs and practices, different management and managers, variations of farming systems, variations of climate. In many things the changes are not big, but they present problems and have to be studied. This is a typical real-life learning situation. If the officer is an effective learner he will quickly gather information and develop the knowledge and the skills needed to give him success in the new situation.

As we become more conscious of the fact that **problem-solving and learning are much the same thing**, we realise that effective learning does not belong to the classroom, but to everyday real-life situations and experiences. Whether we realise it or not we all attend the University of Life!

THE LEARNING CYCLE

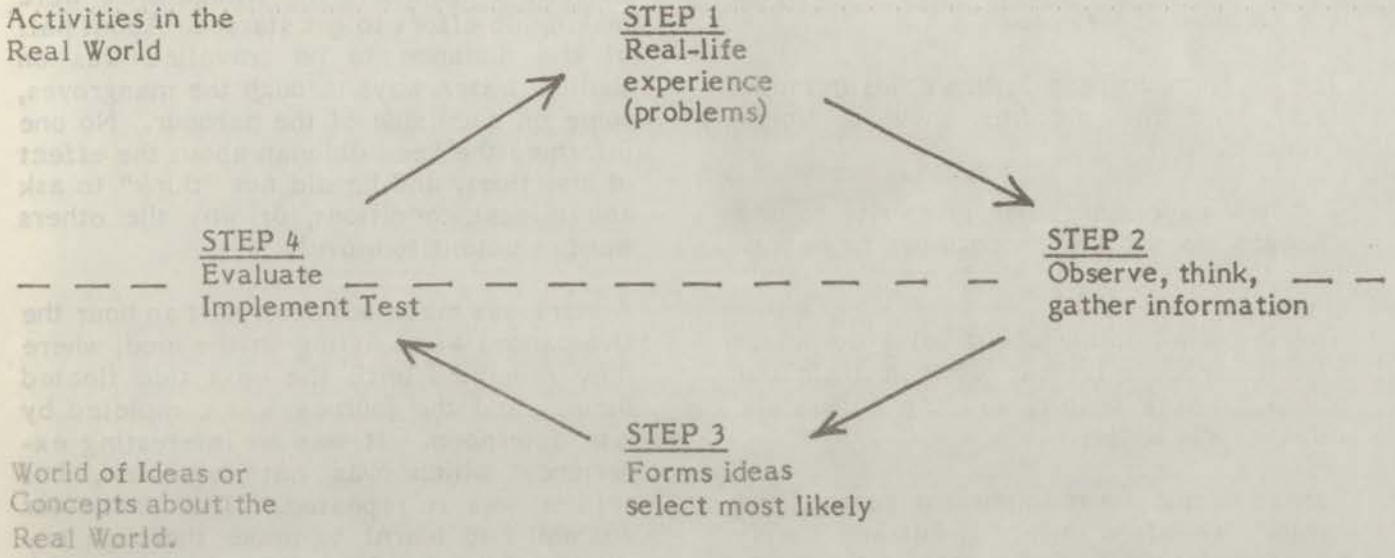
The "experience-based" learning we have been talking about follows a cycle containing four major steps. If we are aware of this, we can greatly improve our learning ability. The usual pattern of the cycle is:

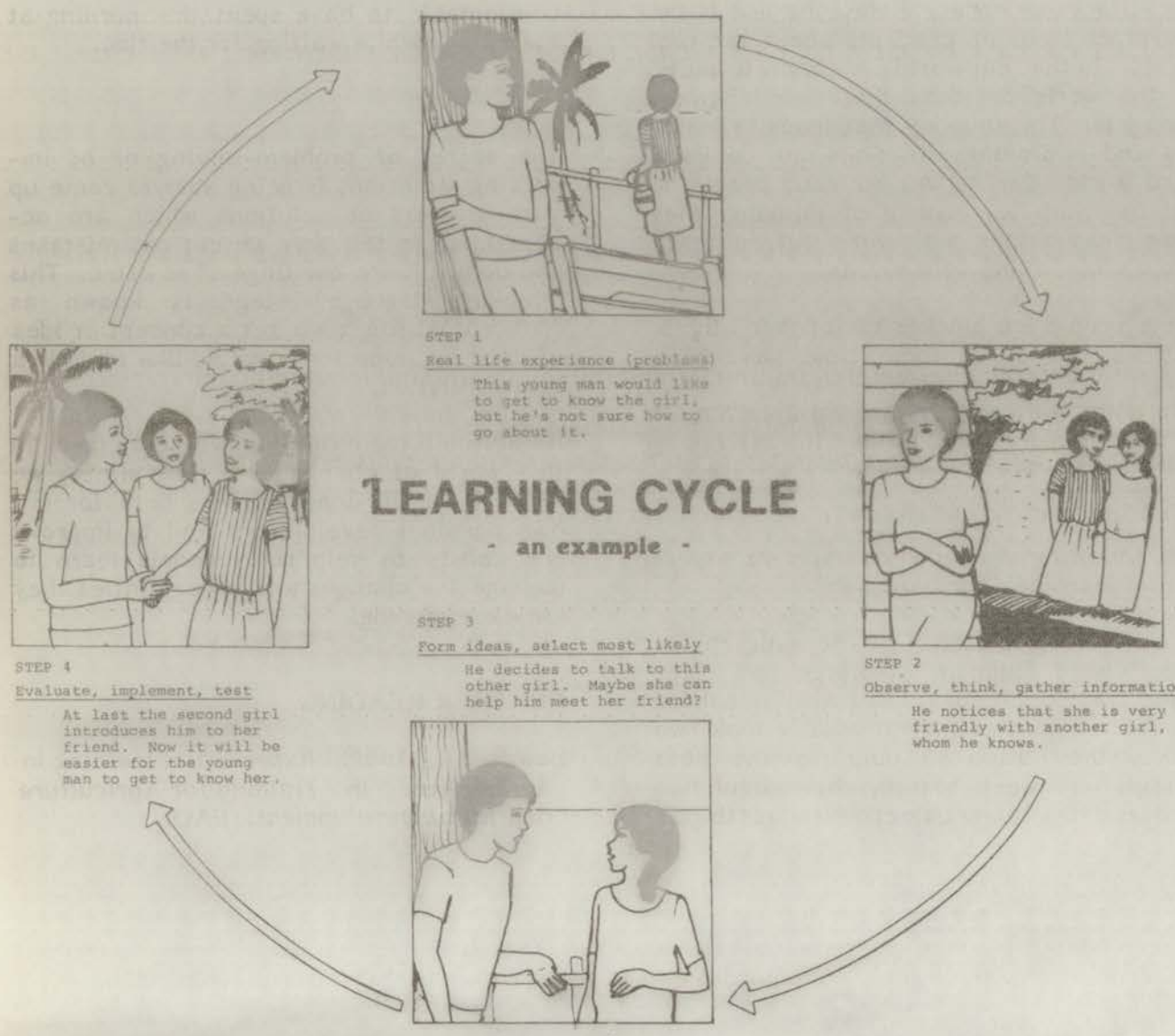
1. A person (the learner) comes up against some real experience which presents a problem or a difficult situation.

2. The person observes and thinks about this.

3. Various ideas for possible action come to mind as the learner tries to find out what is needed to allow for improvements or solutions.

LEARNING CYCLE





4. A decision is made to test and apply new ideas until effective action can give an acceptable change in the problem experienced

The diagram on page 3 shows this in model form, and the pictures show a simple example.

The new experience then gives rise to new changes, so the cycle continues to be followed.

The important thing about being conscious of this process is that we can train our minds to work better, and can understand other people better.

Step 3 is the most important part of the cycle. We often miss this out and simply try the first thing that comes to mind. In the diagram the dotted line indicates a boundary between two worlds. On the top side is the Real World of activities and real-life experiences. Below the line is the World of Ideas or concepts about the real world. In the real world are concrete facts, in the world of ideas there are abstract thoughts. The thinking that leads to learning and improving situations can be quite hard work! This is why so many people do not use Step 3. Instead of thinking, they hope that things will work out, or they simply drift along with events.

Some people are quicker to act than others, but all of us at some time have been caught out when acting "before we think." Too often we jump from Step 2 to Step 4 without thinking through the alternatives by entering the World of Ideas.

The following is a good example of experiential learning - the hard way!

A certain agricultural patrol with an inexperienced didiman in charge had clear objectives for the day: to travel by canoes across the harbour, which usually took two hours, then walk an hour to the next village. A week before, this patrol had achieved the same objective in getting to the village where they now were. This time, however, the didiman saw that both the patrol team and the village crew were making no effort to get started. About half of the distance to be travelled was on shallow water-ways through the mangroves, some on each side of the harbour. No one informed the keen didiman about the effect of the tides, and he did not "think" to ask about local conditions, or why the others were reluctant to move!

A start was made but after half an hour the two canoes were sitting on the mud, where they remained until the next tide floated them - and the journey was completed by late afternoon. It was an interesting experience which was not regretted, but neither was it repeated. This particular didiman had learnt to make thorough enquiries about local conditions, and to seek reasons when he noticed others were reluctant to do something. It would have been more productive and a lot more comfortable to have spent the morning at the village while waiting for the tide.

The secret of problem-solving or of improving situations is being able to come up with answers or solutions which are acceptable. In this way we cut out mistakes and do not "burn our fingers" so often. This "thinking through" stage is known as "conceptualising"; we get a concept or idea of what we hope for or would like to do in a given situation.

As agricultural extension workers, then, in this world of change and uncertainty, we need to be life-long learners both for our own personal development and to improve our ability to help rural people learn to manage the changes and uncertainties they are experiencing.

FURTHER READING

Bawden, R. (1982). Experiential learning in agriculture. In *Training for Agriculture and Rural Development*. FAO.

ROCK MELONS AS A CASH CROP IN THE MARKHAM VALLEY

By Warren C. Antonio, Co-ordinator, Food Crops,
D.P.I., Department of Morobe Province

INTRODUCTION

If you happen to be flying over the Markham Valley in the Morobe Province, you may notice scattered over the ground in some areas many round yellow fruits. These are rock melons or cantaloupes. Many people enjoy this delicious fruit just as much as the big, red, juicy watermelons.

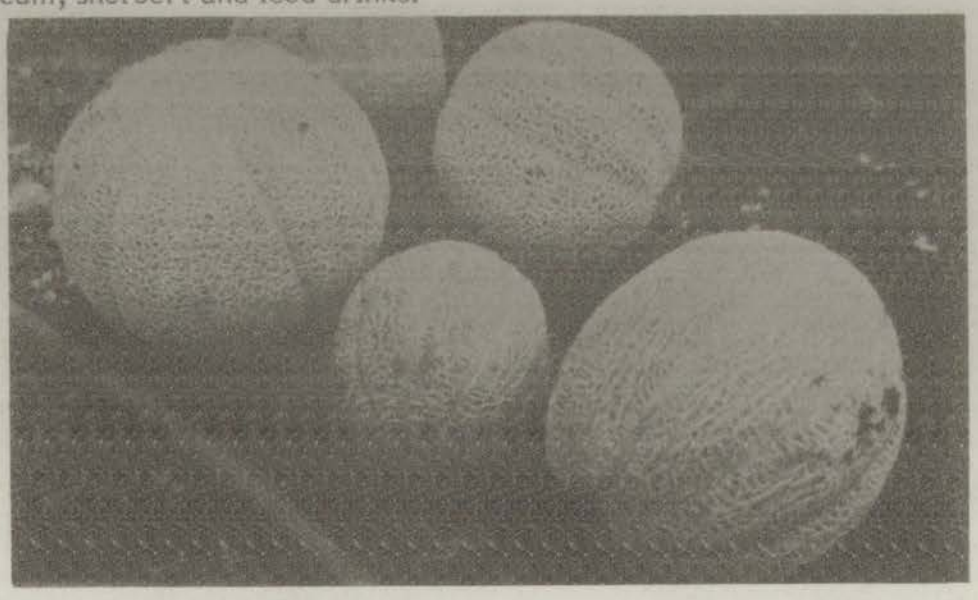
Rock melons were introduced as a cash crop in the Morobe Province in 1979. Since then, they have become more popular and are more common in local shops and markets. In the lowlands of Morobe Province conditions are suitable for rockmelon cultivation. They can be grown as a profitable cash crop.

Rock melons are used as desserts, and in making ice-cream, sherbert and iced drinks.

Before the government's ban on the import of fruit and vegetables, half the local supply of rock melons came from overseas. After the ban, local supply could not meet the increasing demand for this fruit. For this reason, the Food Crops Section of D.P.I. in Morobe Province decided to promote rock melon as a cash crop.

DESCRIPTION

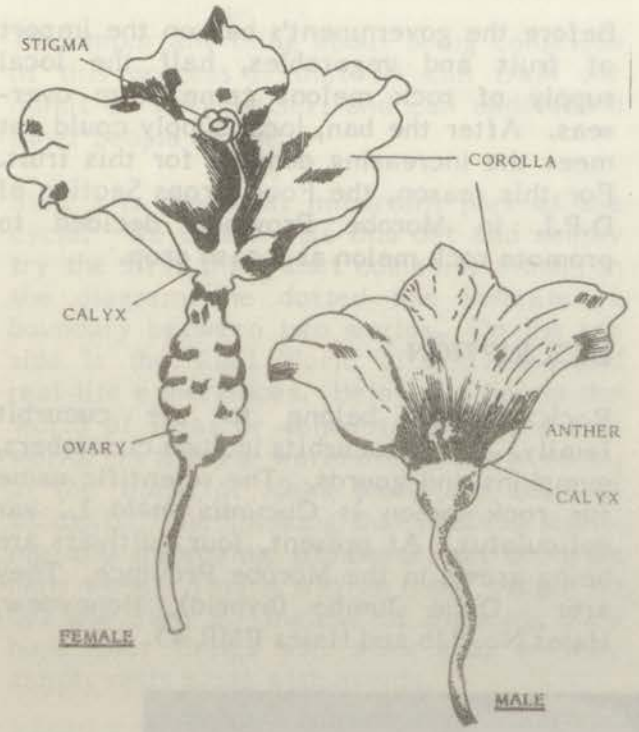
Rock melons belong to the cucurbit family. Other cucurbits include cucumbers, pumpkins and gourds. The scientific name for rock melon is *Cucumis melo* L. var *reticulatus*. At present, four cultivars are being grown in the Morobe Province. They are: Dixie Jumbo (hybrid), Honeydew, Hales No. 93b and Hales PMR 45.



Rock melon fruits. The large ones are Dixie Jumbo (hybrid) and the smaller fruits are Hales PMR 45. D.P.I., Lae is recommending Dixie Jumbo for Markham Valley farmers.

The vegetative parts of rock melon plants are similar to those of cucumbers and gourds. The leaves are smaller, light green and hairy.

Rock melon is a cross-pollinated crop. That is, plants bear either male or female flowers, and the fruits develop from the female flowers which have been pollinated by insects. The diagram shows the male and female flowers.



Female and male flowers of the rock melon. About 6 times actual size.

Except for the Honeydew variety, rock melon fruits have rough, netted skins with a hard rind, and are usually light greenish-white. The Honeydew melon has a smooth yellow skin.

Fruit size varies from about 12 cm diameter and 1.2 kg to 16-17 cm diameter and 3 kg.

All the cultivars have sweet-tasting firm flesh, which ranges in colour from orange to light yellow to green.

The following suggestion for growing rock melons apply to all 4 cultivars.

A rock melon growing demonstration project at Erap, Markham Valley. This is one of the projects set up by D.P.I., Lae to promote rock melon as a cash crop in the area.

CULTIVATING ROCK MELONS

Of the 4 cultivars grown in the Markham Valley, Dixie Jumbo (hybrid) gives the highest yields, and is specially recommended for this area. However, the other varieties are also suitable for growing commercially.

Climate and soil

Rock melons do best in temperatures of 18° to 24° C, and can be grown up to altitudes of 1000 m above sea level. They prefer areas which have distinct wet and dry seasons. The crop is usually planted towards the end of the wet season when the weather is cooler.

Sandy loam soils are suitable for growing rock melons. The soil should have a high content of organic matter. NPK fertilizer may be required. Recommendations for applying fertilizer are given in Table 1.

Preparing the ground

In the Markham Valley, if virgin kunai land is being used, first cut the kunai with a slasher, leave it to dry, then burn it. Prepare the land 2 or 3 days later.

TABLE 1. RECOMMENDED RATES OF FERTILIZER FOR GROWING ROCK MELONS IN THE MARKHAM VALLEY

Kind of fertilizer	Time of application	Application rate	Method
Complete (NPK 12:12:12) (plus animal manure)	At planting	10 g* per hill (equivalent to 50 kg per hectare)	Basal
Muriate of potash + solophos in 1 : 6 ratio	Post emergence at 4 - 5 leaf stage	10 g per hill	Side dressing
Muriate of potash + solophos in 4 : 6 ratio	Post emergence 1 week later	10 g per hill	Side dressing
Complete	When vines are 1 metre long	10 g per hill	Side dressing
Complete	First fruits are the size of an egg	10 g per hill	Side dressing

10 g is about half a matchboxful

Plough the land to about 20 cm deep, then harrow to break up the larger lumps of soil. A rotavator is sometimes used just after harrowing or just before planting.

For land which has been previously used for root crops, such as peanuts or kaukau, burned plant remains should be thoroughly mixed with the soil.

Spacing

In the Markham Valley, the recommended spacing for planting is 1 metre between hills and 2 metres between rows. This recommendation is based on yield trials and seems to give the best results.

Rock melons need plenty of sunlight to produce good stalks, leaves, roots and fruits. If they are planted too close together, the vines become overcrowded and each plant receives less sunlight. This results in a reduced yield of fruit.

Planting

Plant 4-5 seeds per hill. If either organic or chemical fertilizers are being used, they should be mixed thoroughly with the soil at planting. Add to the soil where the seeds are to be planted Captan, or Brassicol at 3 tablespoons per 4 litres of water. This is to control diseases carried on the seeds. Drenching should be just enough to wet the soil.

Thinning out seedlings

After the first 2 leaves have emerged, thin out the weakest seedlings, leaving 2 plants per hill. Cultivate between the plants regularly until the vines start to grow together. This helps to stop weeds growing.

Mulching

A mulch of dry grasses can be applied around the young plants when they are

growing well. Mulching helps to hold moisture in the soil, adds nutrients and helps to control weeds. Mulching is only necessary during dry weather. During heavy rains mulching may cause fungal diseases to develop.

Fertilizers

Fertilizer may be applied at planting, during the early vegetative growth, at flowering and at fruiting. The recommendations for the Markham Valley are given in Table 1.

Thinning of fruits and vines.

As soon as the fruits have formed, 45-50 days after planting, remove the vines which have no fruit. This will allow more plant food to reach the vines on which fruit is growing. We recommend that some fruits are removed if there are more than two growing on the same vine. For the best yields, only one or two fruits per vine should be allowed to develop to maturity.

Rearranging fruit

When the fruits begin to develop, place a layer of dry grass 5-6 cm thick beneath each one. This helps to protect the fruits from pests and diseases which may be in the soil. The mature fruits should be turned regularly so that all sides are exposed to sunlight. Turning also ensures that one part of the melon does not always stay damp where it touches the ground. A damp area could become a breeding place for insects which could damage the fruit and cause it to rot.

Irrigation

Rock melons need a good water supply especially at planting, early vegetative growth, flowering and when the fruits have developed. Irrigate once a week at these stages, if there is no rain. Also irrigate after each application of fertilizer. Do not irrigate after the fruits have matured.

Pests and diseases

The pests that attack rock melons are the same as those which attack watermelons and other cucurbits. Entomology Bulletins Nos 40, 41 and 42 in Harvest Vol. 11 No. 4 give details of the common pests of cucurbits and their control.

Rockmelons may be affected by downy and powdery mildew and mosaic virus. The fruit is basically resistant to downy and powdery mildew.

Harvesting

Rock melons can be picked at the 'full-slip' stage or the 'half-slip' stage. 'Full-slip' melons are those which separate easily from the plant leaving a clean stem cavity. 'Half-slip' melons are less mature, are more difficult to detach and about half of the stem stays attached to the fruit.

Both stages are fully netted and the colour has changed from green to mottled green and yellow, or yellow.

STORAGE, TRANSPORT AND MARKETING OF ROCKMELONS

Rock melons can be stored at room temperature for 2 to 3 days after harvesting. Make sure that the room is free from crawling insects like cockroaches. For transport to markets or stores, the melons should be carefully arranged in wire crates or cardboard cartons. The least ripe (that is, the firmest) fruit should be put on the bottom, with the more ripe melons on top. Take care not to expose the fruit to strong sunlight for a long time.

In Lae, the wholesale price for rock melons varies from 60t to K1.50 per kilogram, depending on the supply and demand situation. In supermarkets in Lae, the selling price for rock melons can be as much as K2.50 per kilogram.

It seems that at present the demand for rock melons is increasing, while local supplies are unstable.

SEED SUPPLY

In Lae, rock melon seeds can be obtained from the following suppliers: ICI, Niugini

Produce Marketing, Stockman, Niugini Pastoral Supply, Steamships and Burns Philp. Farmers should consult their local D.P.I. Extension Officer before buying seeds. In Lae, advice can be obtained from the author at 3 Mile D.P.I. Office.

FURTHER READING

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Sutherland, J.A. (1986b). Pests of cucurbits 2. Black leaf-footed bug. Entomology Bulletin: No. 41. *Harvest* 11 (4): 156-158.

Sutherland, J.A. (1986c). Pests of cucurbits 3. Minor pests of cucurbits. Entomology Bulletin: No. 42. *Harvest* 11 (4): 159-163.

RICE IN PAPUA NEW GUINEA – AN ECONOMIC EVALUATION

By James Joughin, Senior Agricultural Economist, D.P.I., Konedobu

INTRODUCTION

The subject of rice is often in the news in Papua New Guinea. Practically everyone eats it and yet it is almost entirely imported - and these imports are rising. In 1963 less than 30,000 tonnes of rice were imported into Papua New Guinea; by 1985 this had risen to nearly 110,000 tonnes.

Rice has been grown on and off for 95 years in Papua New Guinea. There have been rice projects in Kokopo, Alexishaven, in the Mekeo, Gulf, Talasea and in Milne Bay. They have all failed. Common features in all the failures have been:

- the large amount of labour required to grow rice
- the poor returns to investment (a low price for the crop compared with the cost of producing it).

For example, 20 ha of irrigated rice in Alexishaven was abandoned after 3 years in 1913. The cost of labour was too high. Fifty years later commercial rice in Milne Bay was abandoned for the same reason.

Although these rice projects have failed, many people still think that Papua New Guinea should grow its own rice. For this reason D.P.I. invited the Food and Agriculture Organisation of the UN (FAO) to send a team of advisors to look at rice in Papua New Guinea. The team's job was to assess the costs and benefits of different policies towards rice.

A team of economists visited Papua New Guinea in October and November 1985. They toured the rice-growing provinces and had discussions with the concerned Departments. Their report is now complete. The conclusions of the report are discussed in this article.

Rice ready for harvesting. Rice has become a major food item in Papua New Guinea, yet most of it is imported. Should we produce our own rice?

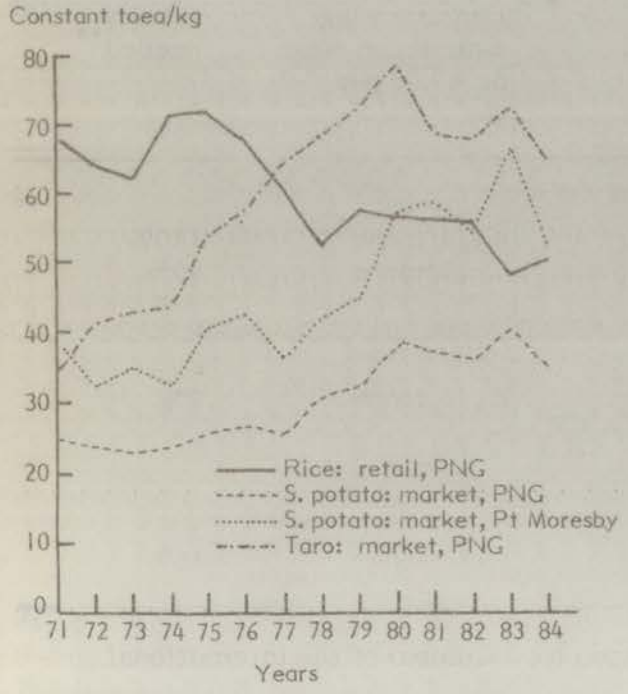
CONSUMPTION

Papua New Guineans choose to eat rice because, compared to traditional staples, it has the following advantages:

- it is less bulky and therefore easier to carry
- it stores better
- it is easier to prepare and cook
- it is often cheaper.

The graph below compares the price of rice (in toea per kilogram) with the price of sweet potato and taro in urban (town) markets. It shows that rice is cheaper than taro, and in Port Moresby rice is also cheaper than sweet potato. Nationwide, rice is now only a little more expensive than sweet potato. If we compare the price of rice and the price of traditional staples according to their nutritional value we find that rice always works out cheapest in urban areas.

As incomes have risen, so people have eaten more rice. The amount of rice eaten in Papua New Guinea is expected to continue to rise. The FAO team estimated that by 1995 we could be importing as much as 200,000 tonnes per year.



This graph shows how prices have changed from 1971 to 1984 for rice and some traditional staples. The price of rice has fallen, while sweet potato and taro prices have risen.

The rising level of rice imports is connected with the successful government policy to expand export crops. Farmers have made money from growing export crops and as labour and land have been transferred from food gardening into cash cropping, so the demand for store foods like rice and tinned fish has risen.

In 1984, over the whole of Papua New Guinea, the average amount of rice eaten was about 33 kg per adult. The situation in urban areas differs from that in rural areas.

Urban areas

The consultants estimated that in urban areas people ate about 80 kg rice per year - a very high quantity which probably will not grow much higher.

People in towns are already used to a high-rice diet, and it would be difficult and unpopular to try to control rice consumption by, for example, raising the price.

Far fewer people in Papua New Guinea live in the towns than in the villages. Thus, the total rice consumption in towns was only about 30% of the national total in 1984.

Non-urban areas

In non-urban areas, the consultants estimated that people ate only about 26 kg rice per year. So here, there is plenty of room for growth in demand. It may be possible to prevent the increasing demand. Ways of doing this include:

Increasing the price of rice by either an import tariff or a tax. This would be unpopular and politically difficult. At the time of writing it seems that the price is set to go down, with the possible import of cheap surplus rice from the U.S.A. This will please consumers, but it will harm the people who produce traditional foods. Their markets must have already been affected as people have switched to eating rice.

Improving the marketing of traditional staples to reduce the price.

- Trying to increase the efficiency in production of traditional staples to reduce the price.
- Trying to develop substitute foods such as processed roots and tubers.

A future FAO study will investigate these choices.

PRODUCTION OF RICE IN PAPUA NEW GUINEA

Many people have said that the obvious way to reduce the growing import bill for rice is to produce rice here in Papua New Guinea.

The FAO team carried out an evaluation of 5 different systems of rice cultivation. That is, they estimated the costs of setting up and operating each system, and compared these costs with the expected revenue from selling the rice.

Table 1 shows the costs and returns (income) for 3 smallholder systems of growing rice. Table 2 shows the costs and returns for 2 commercial (large scale) systems.

According to the consultants only one system could be profitable. This is double cropped rainfed rice. Very limited areas may exist in Papua New Guinea where there is enough rainfall at the right times for double cropping (two crops every year). However a lot of money is needed to set up a commercial rice project. Foreign investors would have to provide this money, and they would no doubt require long term price guarantees from the Papua New Guinea government.

In all the other systems of growing rice, the only way in which farmers could make enough money would be for the government to subsidise the price. That is, the government would have to pay the farmer an amount above the price he would normally

TABLE 1. THREE SYSTEMS OF SMALLHOLDER RICE PRODUCTION

Production system	Capital needed to set up project	Returns for 1 man-day of labour if rice sells at K153/tonne*	Cost of production assuming a minimum wage of K3.50 per day is paid	Percent subsidy needed**
1. Rainfed upland				
a) traditional	Nil	K1.00	K428/tonne	180%
b) improved	K550/20 ha	K2.28	K214/tonne	40%
2. Irrigated semi-mechanised	K6000/20 ha	K3.25	K156/tonne	2%
3. Rainfed - with mechanical services	K9000***	K2.35	K181/tonne	18%

* *K153/tonne is the farm gate equivalent (in Papua New Guinea) of the international rice price, averaged over 1981 to 1985.*

** *The figure given is the percentage of the market price (K153/tonne) which the Government must add to the price for the grower to be able to pay the minimum wage for labour.*

*** *This figure is the cost of purchasing machinery which can service 200 to 400 ha.*

receive at the market. The average world market price over the last 5 years was K153 per tonne. The subsidies needed for each system in Table 1 and 2 are shown as a percentage of this price.

The team especially looked at the possibilities for smallholder production. Unfortunately, returns to labour (the amount of cash earned from the crop compared with the cost of labour) for rice are not very attractive when compared to alternative crops. This is shown in Table 3. Farmers will not choose to produce a crop which does not yield a good income, however much the government tries to persuade them. Again, if the government wants smallholders to grow rice, it will have to pay them a subsidy.

It is not just poor returns to labour that has caused farmers to stop growing rice. It is also the type of labour needed. Rice needs attention every day and for long periods. The work is not very pleasant as the farmer has to spend a lot of time standing in water or mud. The Papua New Guinean farmer prefers low maintenance crops which allow time for many other daily tasks and social activities.

The consultants made the following two suggestions:

1. In areas where there is no alternative cash crop to rice, e.g. around Angoram in the East Sepik Province, the government might consider subsidisation. This would help bring income into a disadvantaged rural community.

2. Rice could be introduced into the garden system as a food crop. This might reduce the labour requirement for the crop as other garden crops would be tended at the same time. If this is to reduce the demand for imported rice from trade stores,

TABLE 2. TWO SYSTEMS OF COMMERCIAL (LARGE SCALE) RICE PRODUCTION

Production system	Capital needed to set up project (investment)	Returns to investment if rice sells at K153/tonne*	Paddy price needed for a 12 per cent return (profit)	Percent subsidy needed**
4. Rainfed mechanised				
a) 200 ha single cropped	K225,000	negative	K225	47%
b) 500 ha single cropped	K394,000	negative	K290	90%
c) 200 ha double cropped	K225,000	12%	K153	none
5. Irrigated large scale (2000 ha)	K10.9 million	negative	K257	68%

* *See Footnote * in Table 1.*
** *See Footnote ** in Table 1.*

farmers would have to change their ideas. They would have to be prepared to grow their own rice. At the moment rice is seen as a cash crop only. The FAO team recommended that D.P.I. research the possibilities of rice as a food crop only. Already some research is underway.

The FAO report does not recommend any particular production system. It simply presents an economic evaluation of the available data, which is summarised in Tables 1, 2 and 3.

TABLE 3. Smallholder returns* per day of family labour, for various crops

Crop		Returns for one man-day of labour
Upland rice:	traditional	K 1.00
	improved	K 2.28
	semi-mechanised	K 2.35
Irrigated rice:		K 3.35
Sweet potato (highlands)		K 2.10 - K 3.10
Maize		K 3.55
Cassava		K 2.00
Rubber (smallholder/ /nucleus estate)		K 1.00 - K 1.40
Coffee, arabica,	average	K 1.30 - K 2.70
	improved	K 4.00 - K 5.20
Cocoa and coconut		K 8.00 - K 9.00

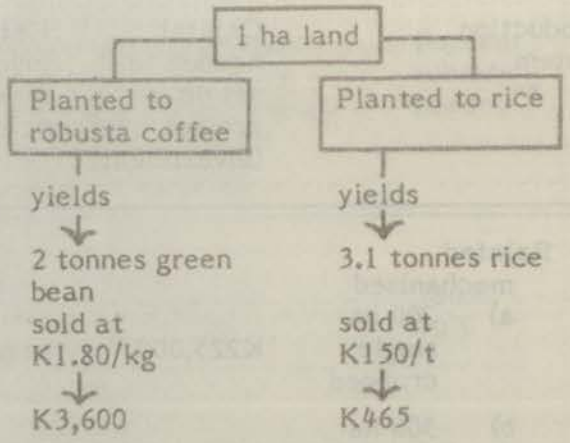
* *Tree crop returns have been averaged over the life of the tree to make them comparable with returns from annual crops.*

If Papua New Guinea decided to produce its own rice, then the appropriate production method world be the one which requires the smallest subsidy per unit of foreign exchange saved. The report shows that this is smallholder rainfed rice, with mechanical services provided. This would require a subsidy of 18% from the Government.

On the other hand, a large-scale irrigated rice project like that proposed for the Mekeo region would need a subsidy of 50% to 70%. It is estimated that a 2000 ha project could produce about 6% of Papua New Guinea's present needs. This would cost the Government K1 million per year in subsidy. Therefore if the whole of Papua New Guinea's rice needs were grown here, it would cost K17.3 million per year in subsidies. The FAO team suggest that this money would be better spent on tree crops.

The following simple example shows why:

Let us take a 1 ha area of land. What are the returns from growing coffee and what are the returns from growinig rice?



Thus by growing robusta coffee, the farmer would receive 7.7 (i.e. 3600/465) times as much money for his crop, than if he grew rice.

Of course, the country must be prepared for a possible fall in revenue from its cash crops. D.P.I. estimated in 1985 that cash crop earnings would rise. We did not foresee the outbreak of coffee rust. The real effects of the disease on the coffee industry are still not known. However the coffee rust outbreak has made us think again about the country's dependence on

imported foods. If the nation earns plenty of foreign exchange then it can afford to import food. If these earnings are reduced, it is not easy to change people's eating habits.

CONCLUSION

The FAO team have produced a report which is intended to help Papua New Guinea in making policy decisions. The report makes only a few recommendations. These are mostly concerned with:

- making substitues for rice more competitive (cheaper or more attractive to buyers)
- research into growing rice as part of the traditional garden system
- monitoring the existing food crops marketing system in order to try to improve it
- expanding food policy research.

It is up to Papua New Guinea to use the information in the report to make wise decisions about rice policy in the future. D.P.I. has known for a long time that rice is not a profitable crop for our farmers. This report includes calculations which show just how much a rice production programme could cost. It seems that the wisest course is to reject rice production.

However, we must try to reduce the rate of growth of rice demand; probably the only way this can be done is through the efficient production and marketing of traditional staple foods. Taxes or import quotas on rice will not be acceptable, but if traditional staples can be made cheaper, then there is hope that people will eat them more.

FURTHER READING

FAO (1986). Rice development policy. An analysis of the options for meeting future rice requirements. FAO: Rome.

Author's Note

Since this article was submitted inter-national prices for coffee have fallen considerably. Farm gate prices for robusta are now about K1.00/kg. This means that, in the example given in the article, revenue from 1 ha of coffee would be some K2,000. The coffee producer's comparative advantage over the rice producer has therefore now fallen to just over 4:1. In a sense the argument is reinforced. Despite a 44 per cent fall in the farm gate price of coffee the coffee producer is still markedly better off than the rice producer.

James Joughin

CHARCOAL - A USEFUL ADDITIVE TO FERTILIZER FOR CORAL SOILS AN EXPERIMENT IN TUVALU

By K. Trewren, Agronomist, Department of Agriculture, Kiribati

INTRODUCTION

Growing food on coral soils is often a problem because:

1. The soils are low both in organic matter and in the important plant nutrients nitrogen, potassuim and certain trace elements.

2. Often the concentration of salt is very high.

3. There is a limited supply of fresh water on many coral atolls.

It is possible to grow a good range of vegetables on these soils, but only if expensive fertilizers are used.

In 1981, agronomists from the Department of Agriculture, Tuvalu, began a trial to find a local substitute for imported fertilizer. The trial was carried out on Vaitupu Island, Tuvalu.

FERTILIZER TREATMENTS

The trial consisted of 15 treatments on plots of coral soil, growing Chinese cabbage (variety Chinese Taisai) as a test crop. Each treatment was repeated 4 times, hence there were 60 plots in the trial altogether. Each treatment was a combination of the following conditions.

- cultivation or no cultivation
- fertilizer or no fertilizer
- add ash from coconut wood or no ash
- add charcoal from coconut wood or no charcoal
- add finely ground phosphate rock or no phosphate rock.

Extra sulphate of ammonia (a source of nitrogen) and ferrous sulphate (a source of iron) were added to some wood ash treatments, because it was assumed that wood ash would not contain enough of these nutrients (plant foods).

Table 1 shows the amounts of fertilizer and fertilizer substitutes used during the trial. All the treatments were applied before planting. In the cases of the standard fertilizer mixture, wood ash and sulphate of ammonia they were also applied to each plant once a fortnight at the rate shown.

The trial was designed so that the effects of the various treatments could be seen by comparing pairs of treatments.

RESULTS

Cultivation

There was little difference between the yields produced on cultivated plots compared with non-cultivated plots. This is to be expected on very porous soils. Not much cultivation is needed because the soil particles do not stick together in large lumps.

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* *This article is based on one which appeared in the Alafua Agricultural Bulletin 10(1), 1985, pp. 31-33.*

TABLE 1 RATES OF FERTILIZER AND FERTILIZER SUBSTITUTES USED IN THE TREATMENTS

Treatment	Amount applied before planting	Amount applied after planting
Standard fertilizer treatment	100 kg/ha ferrous sulphate plus 500 kg/ha standard fertilizer mixture*	5 g mixture* per plant per fortnight
Wood ash	1000 kg/ha	5 g per plant per fortnight.
Charcoal (lumps)	1000 kg/ha	-
Ferrous sulphate	1000 kg/ha	
Phosphate rock	1000 kg/ha	-
Sulphate of ammonia	300 kg/ha	1 g per plant per fortnight

* *The standard fertilizer mixture was made up as follows:*
10 kg Ammonium nitrate
10 kg IBDU (Isobutylidene duirea - 32%N)
10 kg Potassium chloride
6 kg Double superphosphate
5 kg Ferrous sulphate
5 kg "Essential mineral elements" - Ess-Min-El.

Fertilizer

The plots treated with the standard fertilizer treatment compared to those without it showed the greatest effect. For example, on uncultivated soil, Chinese cabbages grown without fertilizer weighed on average only 8.7 g; with fertilizer the average weight was 610 g. On cultivated soils the weights were 23.2 g per Chinese cabbage, unfertilized; and 670 g, fertilized.

Wood ash

The addition of wood ash did increase yields compared with the unfertilized control. However the increase was much lower than that obtained after using the standard fertilizer treatment. Adding sulphate of ammonia (nitrogen) and ferrous sulphate (iron) did not make much difference.

Phosphate rock

The phosphate rock treatment had no effect on the growth of the Chinese cabbages. It probably did not dissolve enough and therefore could not be absorbed into the plants.

Charcoal

On its own, charcoal did not have a big effect on the crop. Charcoal combined with wood ash, sulphate of ammonia, ferrous sulphate and rock phosphate gave only a small increase in the size of the cabbages. However, when charcoal was added to the standard fertilizer treatment the average weight per cabbage increased from 670 to 815 g. The charcoal and standard fertilizer treatments together gave a better result than any other combination.

DISCUSSION

In this trial, the charcoal was spread on the plots as lumps, then the fertilizer was added. Both were then dug into the soil together. It is thought that charcoal improves the effect of fertilizer because the nutrients somehow stick to the surface of the charcoal. This prevents them from draining away through the soil.

Thus, this experiment shows that if charcoal is added to fertilizer on coral soils, the effect of the fertilizer is improved. There are still many questions to be answered.

For example:

1. How much charcoal should be used?
2. Should charcoal be applied as lumps or powder?
3. Should charcoal be mixed with fertilizer before applying to the soil?
4. Do other crops respond as well as Chinese cabbage?
5. Does charcoal need to be applied to the same piece of land every year?

In spite of these questions, the author thinks that the use of charcoal as an additive to fertilizer is a promising line of research. It could be of special value on coral islands.

FURTHER INFORMATION

Further information about the trials using charcoal and fertilizers on coral soils can be obtained by writing to:

The Agricultural Officer
Ministry of Commerce and Natural Resources
VAIAKU
Funafuti
Tuvalu

or Chief Agricultural Officer
Ministry of Natural Resources Development
Division of Agriculture, Tanaea
P.O. Box 267, BIKENIBEU
Tarawa
Kiribati

Further information about soils, fertilizer use and land suitability in Papua New Guinea can be obtained by writing to:

Chief Land Utilisation Officer
P.O. Box 1863
Boroko, N.C.D.

FURTHER READING

Lefroy, E. (1981). Growing food on coral atolls. *Harvest* 7(1):7-13.

Tuvalu Department of Agriculture (1981). Annual Report 1981.

Note from Land Utilisation Section, D.P.I.

Coral soils are found in Papua New Guinea exclusively on some of the low coral atolls along the north coasts of the New Guinea mainland, New Britain and New Ireland, and among the Milne Bay Islands.

They are often left uncultivated because of the problems mentioned in this article. Salt spray is possibly more of a problem than high salt content of the soil.

Coral soils should not be confused with the soils on raised coral terraces which are more widespread. These soils are often very shallow, but are also fertile, with high contents of phosporus, organic matter and some nitrogen.

As far as we are aware the method described in this article has not been tested in Papua New Guinea, but we see no reason why results should be different here.

It should be noted, however, that it is essential to apply fertilizer with the charcoal to achieve any benefit. Charcoal by itself is not enough to improve yields.

D.P.I. ENTOMOLOGY BULLETIN : NO. 43
PSYLLID PEST OF LEUCAENA

By J.E. Moxon, Lowlands Agricultural Experiment Station
Keravat, East New Britain Province

INTRODUCTION

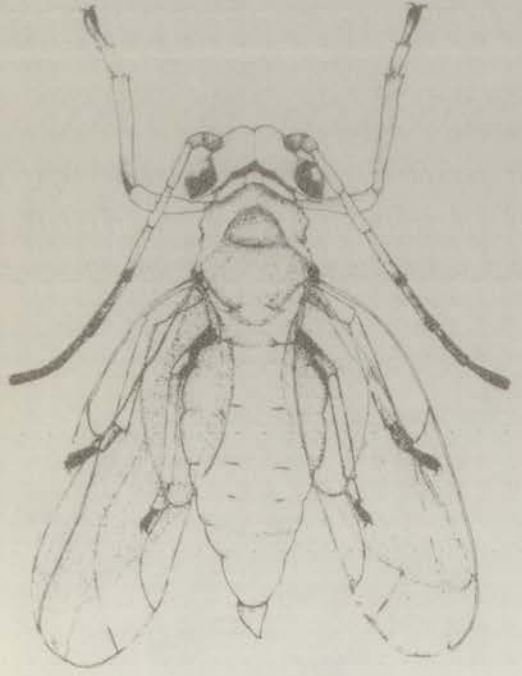
In March 1986, the Department of Primary Industry found a new insect pest which causes serious damage to the tree *Leucaena leucocephala* (local name: lantoro). The insect has been identified as a psyllid. Its scientific name is *Heteropsylla cubana*. The psyllid originally came from the Southern United States and South America. It was probably carried to Papua New Guinea via other Pacific countries by moving air masses. The insect is present on leucaena throughout all lowland areas of Papua New Guinea and also in some highland provinces.

DESCRIPTION

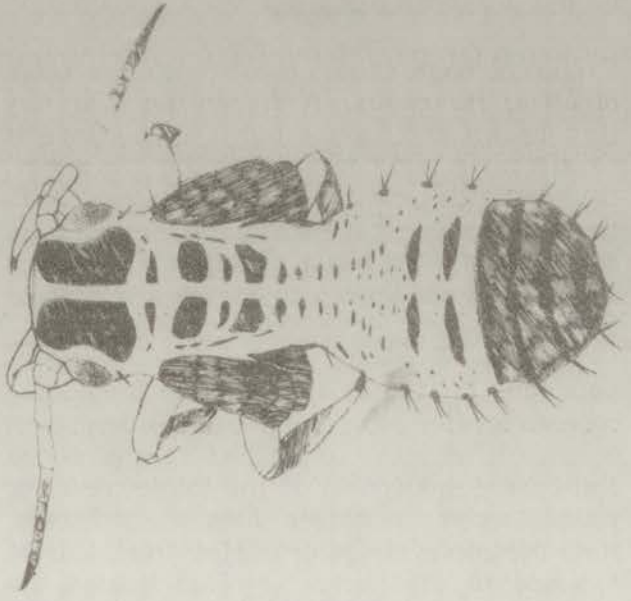
The adults are very small, about 2 mm long, and are green or orange. They have wings and long back legs which they use for jumping - hence their other name, jumping plant lice. The nymphs (young psyllids) are the same colour as the adults. They also have legs but no wings. The best place to see both nymphs and adults is on the young leaves and shoots of leucaena trees.

BIOLOGY

The psyllids lay eggs singly on young unopened leucaena leaves. The eggs are attached to the leaf surface by a stalk, through which juices are obtained. After 2 to 3 days nymphs hatch from the eggs.



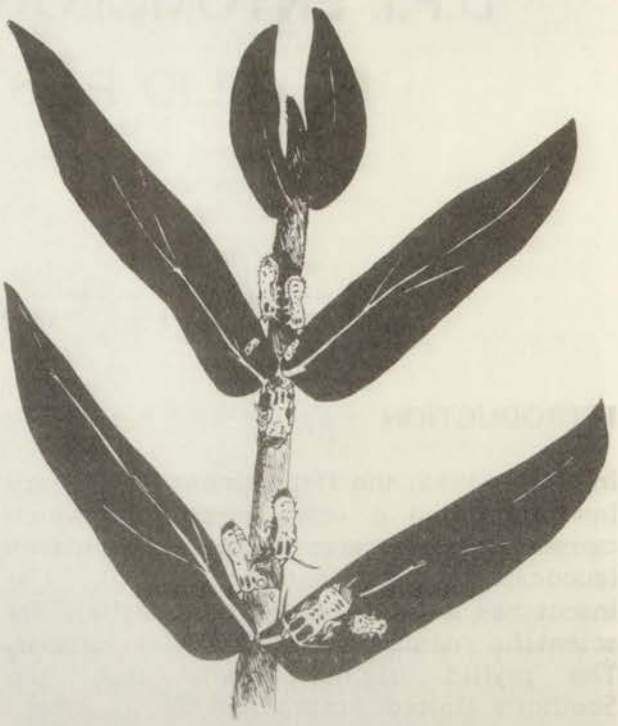
Adult leucaena psyllid, about 35 times natural size



Late nymph of the leucaena psyllid

There are 5 nymphal instars (stages) and altogether they last 8 to 9 days. After this the nymphs change to adults. They mate, and a few days later the female lays eggs. The total life cycle is about 14 days. A female lays about 400 eggs in her life time.

Egg and early nymph of the leucaena psyllid



Nymphs of the leucaena psyllid feeding on a young leucaena shoot

ECONOMIC IMPORTANCE

Both nymph and adult psyllids feed on leucaena. They suck the juices mainly from young leucaena leaves and shoots. They produce a sugary liquid called honeydew. Black sooty mould grows on the honeydew on the leaves and shoots.

Psyllid damage causes the tree to lose some or all of its leaves. Although the tree may turn brown and have a burnt appearance it is still alive and can grow again. However, if the psyllids continue to eat new growth the tree may stay brown and eventually die. Damage is worst during dry weather. The pest is not known to attack any cash or food crops.

Leucaena is used as a shade tree for cocoa, robusta coffee, cardamom and other cash crops. It is most important to the cocoa and coffee industries. If the shade trees for young cocoa or coffee lose their leaves, then the young cocoa or coffee trees will be exposed to the hot sun. This causes the crops to grow poorly or die. If the shade

Young leucaena leaves damaged by the leucaena psyllid

trees over mature cocoa or coffee lose their leaves, then the cocoa or coffee will not die. However, you could lose over 30% of the crop if fertilizer is not applied.

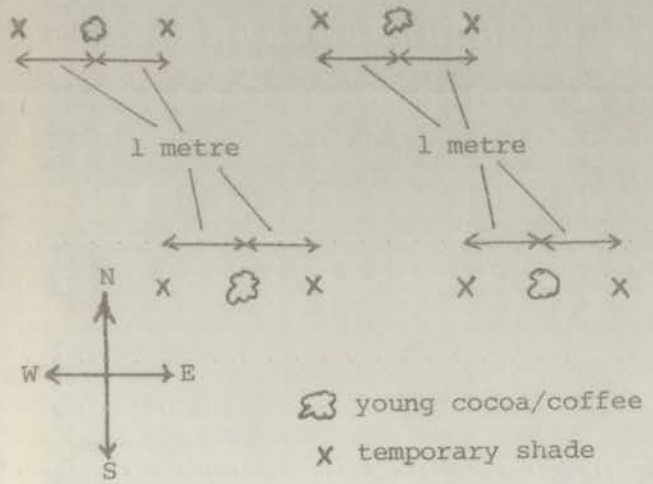
Leucaena is also used for firewood, to prevent soil erosion and as a fodder for livestock.

CONTROL

The best way to control the leucaena psyllid pest is to use its natural enemies (other insects that eat it). We do not know of any good natural enemies in Papua New Guinea, and we will have to try and find them overseas. This may take quite a long time. In the meantime the following methods will help to protect your crops.

1. On young cocoa or coffee up to 9 months old

You can shade young cocoa plants from the hot sun by sticking a coconut frond or bombom into the ground next to each plant. You should then plant a quick growing temporary shade such as pigeon pea or crotalaria. Plant the shade trees on each side of the cocoa or coffee and 1 metre from it in an east-west direction. The trees must grow for about 2 months before they provide good shade. These temporary shade trees will last for about 2 years. If you can not obtain pigeon pea or crotalaria use gliricidia sticks instead.



Plant temporary shade trees about 1 metre from your cocoa or coffee, in an east - west direction, as shown above.

2. On cocoa or coffee trees from 9 months to 18 months old

Larger cocoa or coffee trees need a taller shade tree than pigeon pea or crotalaria. Therefore you should plant gliricidia shade tree sticks, using 1 gliricidia for every cocoa or coffee tree. Use gliricidia sticks that are at least 2 metres long and again plant in an east-west direction. The gliricidia will provide shade after about 4 months.

3. On cocoa or coffee trees older than 18 months

It is very difficult to grow new shade trees in mature cocoa or coffee blocks because there is not much light under the crop trees. Fertilizing the cocoa and coffee trees will prevent crop loss. You should put 100 g of urea or 200 g of NPK or sulphate of ammonia on the soil around each cocoa or coffee tree 4 times a year.

NOTES

1. It is not worthwhile fertilizing old cocoa or coffee trees that have been badly damaged by insects or diseases and are not yielding much crop.

2. Sometimes, in blocks with a mixture of shade trees, such as leucaena, gliricidia, coconuts, betelnut, etc., the cocoa may be over-shaded. In this case, if the leucaena trees lose their leaves, your crop yield may actually increase.

3. Do not kill all the grass and weeds in the block with herbicides. Short grass will help prevent loss of moisture from the soil. You should ring weed the cocoa or coffee trees and slash weeds everywhere else.

4. We can kill the psyllid pests by spraying with insecticides. However, this is very expensive. A lot of chemical is needed for each large tree and also we would have to spray the trees many times each year. The Department of Primary Industry is at present trying to find a cheap chemical method to control the psyllid.

FURTHER INFORMATION

When the Department of Primary Industry finds a good natural enemy of the leucaena psyllid pest and releases it in Papua New Guinea, a revised Entomology Bulletin will be issued, giving details of the new recommendations.

For further information about insect control, contact your nearest DPI entomologist. Entomologists are based at:

PORT MORESBY
DPI, P.O. Box 417,
KONEDOBU
Tel: 214699 Ext 255

LAE
Bubia Agriculture Research Centre,
P.O. Box 1639
LAE
Tel: 424933

MOUNT HAGEN
Kuk Agricultural Research Station,
P.O. Box 339,
MOUNT HAGEN
Tel: 551377

KIMBE
Dami Oil Palm Research Station,
P.O. Box 165,
KIMBE, West New Britain Province
Tel: 935204

RABAUL
Lowlands Agricultural Experiment Station,
P.O. Box Keravat,
East New Britain Province
Tel: 926251 or 926252

Copies of this Entomology Bulletin can be obtained from: The Publications Officer, Publications Section, D.P.I, P.O.Box 417, Konedobu.

(Illustrations: Jackson Kaumana)

D.P.I. ENTOMOLOGY BULLETIN: NO. 44

HUMAN LICE

By J.A. Sutherland*, Senior Entomologist, Bubia Agricultural Research Centre, Lae

INTRODUCTION

Human lice are insect parasites of man. Parasites are animals (or sometimes plants) which live off another animal (or plant) called the host. Lice are ectoparasites - they live and feed on the outside of their host.

There are three kinds of human lice. Each lives on a different part of the body. The head louse is normally found on the head. The body louse is normally found on the body or in clothing. The pubic louse is normally found in the hairs of the pubic area.

The head louse is very common in Papua New Guinea. The body louse is not common. Both these lice are a nuisance to man, because they bite and cause itchy lumps. They can be a health hazard, because they can spread diseases from man to man.

The pubic louse does not spread diseases, but it again is a nuisance because of the itchy lumps caused by its feeding.

THE HEAD LOUSE AND THE BODY LOUSE

Taxonomy

The head louse and the body louse are very closely related. Some entomologists think that they are different subspecies (forms) of the same species, *Pediculus humanus*. Others entomologists give them separate scientific names:

The head louse - *Pediculus capitis*
The body louse - *Pediculus humanus*.

In this bulletin they will be dealt with together, using their common names.

Description

Head lice and body lice are small (about 3 mm long), wingless insects with mouthparts adapted for piercing the skin and sucking blood. They are greyish-brown to dirty white in colour. Their bodies are flattened from top to bottom.

Head lice live on the skin of the scalp, neck and behind the ears. Body lice spend most of their time hidden in the seams of clothing. They only visit the skin to feed.

Biology

The female head louse lays yellowish-white eggs on the base of hairs. The eggs are firmly attached to the hair and are called 'nits'. The female body louse attaches the eggs to the fibres of clothes.

The females lay 8 to 10 eggs per day and can produce 200 to 300 eggs altogether. Nymphs (early stages) hatch from the eggs after about 1 week. The nymphs look like small adults. During the next 4 weeks, the nymphs moult (lose their skins and grow) 3

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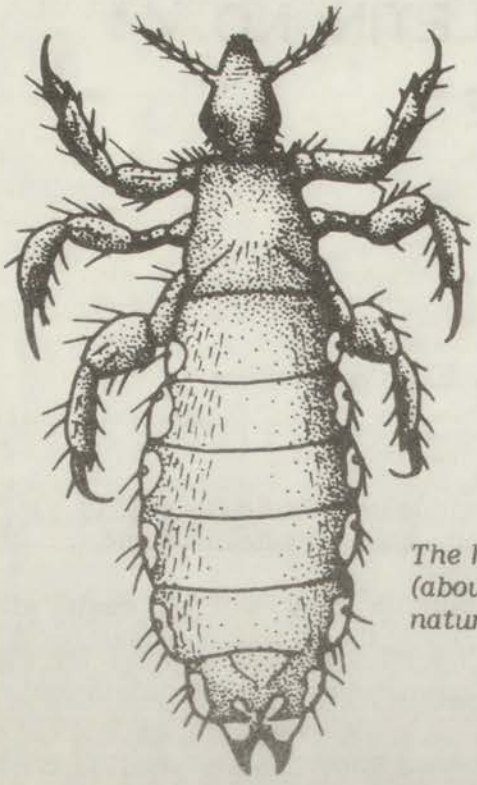
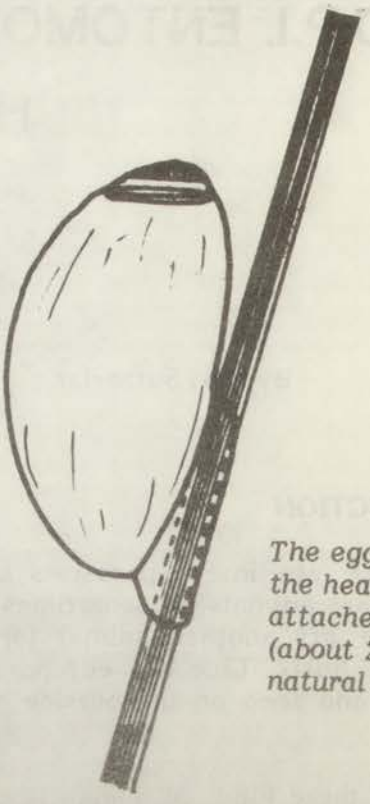
* *Present address: Cotton Research Institute, Old Shujabad Road, P.O. Box 672, Multan, Pakistan.*



The head louse (about 25 times natural size)



The egg ('nit') of the head louse attached to a hair (about 25 times natural size)

times, gradually growing larger and becoming adult. Nymphs and adults bite and suck up blood 2 to 6 times a day.

Once it leaves the host, the head louse dies. However, the body louse can survive for up to a month in damp clothing.

Medical importance

Head lice are extremely common in Papua New Guinea. They spread from person to person by close contact. They are especially common in young children. They are easily spread in schools and within families.

Body lice are not common. They also spread by contact, but they are usually found where people wear heavy clothing. Body lice are only common in tropical countries in highlands areas.

Head and body lice feed by piercing the skin and sucking the blood of the host. The bites of head and body lice are extremely itchy. Scratching can break the skin, and infected sores may develop. The itching also leads to loss of sleep. If an infestation of lice is left untreated for many months, the person may develop a slightly raised temperature and aching muscles, and may feel sick all the time.

Both the head louse and body louse can spread diseases from person to person. However, the body louse is more likely to pass on diseases than the head louse. The three important louse-borne diseases are relapsing fever, trench fever and typhus.

Fortunately, lice do not appear to spread any of these diseases in Papua New Guinea.

Control

Since head lice spread from person to person very easily, they are quite difficult to control. If head lice are found on one member of a family, it is very likely that the whole family will be infected. The whole family MUST be treated at the same time, otherwise the control will not work.

The best treatment is 1% gamma benzene hexachloride (Gamma BHC), known commonly as scabies lotion.

Apply the lotion to about 10 different partings in the hair. Rub into the scalp thoroughly. Take care - do not get the

medicine into the eyes. Cover the hair with a towel or cloth. Wash after 24 hours. After 1 week, repeat the treatment. The dead eggs (nits) should be removed by combing with a fine toothcomb.

Keeping the hair short makes treatment easier. However, do not cut the hair so short that the person feels embarrassed by it. If there are infected sores on the scalp, caused by scratching, the hair should be kept very short until they have healed.

Gamma BHC is available from pharmacies. Commercial shampoos which contain Gamma BHC are also available at pharmacies but they are quite expensive.

DO NOT USE ANY OTHER CHEMICALS TO CONTROL HEAD LICE.

Infestations of body lice can be prevented by regular washing and changing of clothes. If lice are present, the clothes and the person can be washed in a commercial preparation which contains Gamma BHC. These are available from pharmacies and are specially made to control lice. DO NOT USE ANY OTHER CHEMICALS TO CONTROL BODY LICE.

THE PUBIC LOUSE

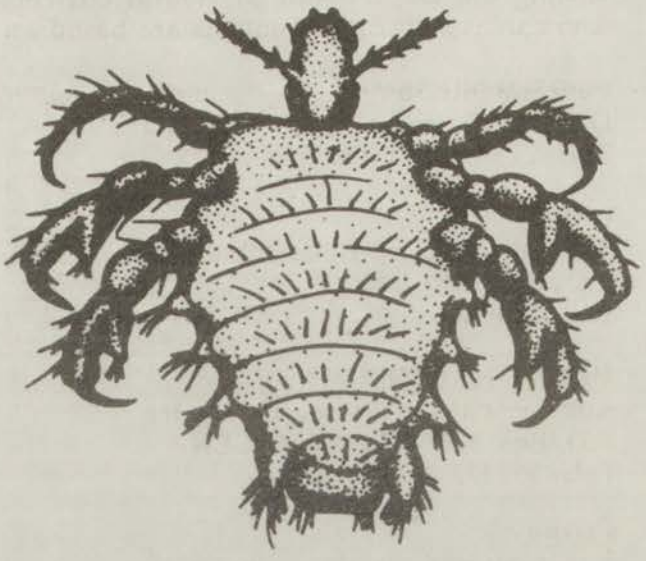
Description

The pubic louse (*Pthirus pubis*) is shorter and rounder than the head louse and the body louse. It is sometimes called the crab louse because its large front legs make it look like a crab. An infested person is said to 'have the crabs'.

The pubic louse is about 2 mm long, wingless, and flattened from top to bottom. Its whole life cycle is spent among the hairs of the pubic region. If many pubic lice are present it may spread to the armpits and beard, but this is unusual.

Biology

The female pubic louse lays 12 to 50 eggs altogether. These are firmly attached to the coarse hairs of the pubic region. Nymphs hatch from the eggs after about one week. The nymphs look like the adults,



Adult pubic louse (Pthirus pubis), *about 25 times natural size.*

but are smaller. Nymphs moult 3 times before becoming adult.

Medical importance

Like the head louse and body louse, the pubic louse feeds by piercing the skin of its host, and sucking the blood. The pubic louse is not known to spread diseases. It is only important because its itchy bites are a nuisance and may cause infected sores to develop. People infested with pubic lice are usually very embarrassed by their condition.

Control

The control measures for the pubic louse are the same as for the head louse and close contact with infested people should be avoided.

FURTHER INFORMATION

For further information and advice about human lice and their control, you should contact your Provincial Health Inspector.

The Department of Primary Industry is not responsible for health matters in Papua New Guinea but you can contact your nearest D.P.I. entomologist for help in

finding the Department of Health Officers who can assist. Entomologists are based at:

PORT MORESBY
D.P.I., P.O. Box 417, KONEDOBU
Tel: 214699 Ext 256

LAE
Bubia Agriculture Research Centre
P.O. Box 1639 LAE
Tel: 424933

MOUNT HAGEN
Kuk Agricultural Research Centre
P.O. Box 339, MOUNT HAGEN
Tel: 551377

KIMBE
P.N.G Oil Palm Research Station,
P.O. Box 165, KIMBE
Tel: 935194

RABAUL
Lowlands Agricultural Experiment Station,
P.O. Keravat, E.N.B.P
Tel: 926251

Copies of this Entomology Bulletin can be obtained from: The Publications Officer, Publications Section, D.P.I , P.O. Box 417, Konedobu.

(Illustrations: R.E. Sutherland)

D.P.I. PLANT PATHOLOGY NOTE: NO. 31

RADOPHOLUS SIMILIS

THE BURROWING NEMATODE OF BANANA

By Elijah C. Philemon, Plant Pathologist,
Agriculture Branch, D.P.I., Konedobu

ITRODUCTION

ıe burrowing nematode, *Radopholus milis*, is a very serious and widespread matode pest in the tropics and sub-opics. It is an endoparasite. An endo-rasite is an organism which lives and eds inside another organism called the ıst. In tropical areas this nematode is ten found with Panama disease of bananas used by the fungus *Fusarium oxysporum*. is an important pest in Australia, Central ıd South America, Africa, the Pacific and e Caribbean.

ıere have only been a few reports of the ırrowing nematode in Papua New Guinea. ır example in 1949, it was reported at two fferent sites in the lower Markham ılley, Morobe Province; and in 1978 it was und at Bomana, Central Province. At ese three places the nematode was sociated with banana plants.

though *R. similis* is present here, Papua ew Guinea is still one of the few countries ıere bananas can grow with few problems used by this nematode. However, grow-s should be aware of the nematode, the seases it causes and the control measures.

OLOGY

ıe life cycle of the burrowing nematode is milar to the life cycles of most nema-des. It consists of the egg, four larval oung) stages, and the adult. From egg to 32°C. This period varies with the temperature of the soil and root tissue.

All stages of the burrowing nematode are infective and are found inside the cortex (outer layer) of the roots of bananas. However, under un-favourable conditions the adults may move out to the root surface and into the soil.

DISEASES

There are two 'biotypes' of the burrowing nematode. Each type attacks different hosts.

1. The 'Banana race' biotype is widespread throughout the banana growing areas of the world. It attacks banana plants only, causing a disease called 'black-head disease'. Other names for the same disease include root rot disease, blackhead toppling disease and decline disease. The banana race is widespread throughout the banana growing areas of the world.

2. The 'Citrus' biotype attacks both banana and citrus plants. At present the citrus race is found only in Florida, U.S.A.

The burrowing nematode attacks other plants including coffee, maize, sugarcane, ornamentals, vegetables, coconut, grasses and weeds. The nematode is also found associated with yellow disease of black

Toppling-over in banana caused by R. similis *infection.*

SYMPTOMS

Symptoms of diseases caused by the burrowing nematode on banana are: reduced size of the bunch and individual bananas; and the banana plant does not grow well; in wet or windy weather, infected plants may easily fall over because damage to the roots and rhizomes causes poor anchorage in the ground. These symptoms are often not easy to see in the plant crop (first crop).

However they become more obvious in the ratoon crop (later crops from the suckers).

The first symptoms of infections are found below ground level. If the roots and rhizomes are dug up, washed and then split open, reddish brown spots can be seen in the infected areas. Later, holes and pink-red streaks (feeding tracks) appear in the roots. On the rhizomes, the outer tissues above infected areas turn black.

In severe infections, the roots rot.

CONTROL

The burrowing nematode is spread by planting infected planting material (suckers). Care should be taken not to transfer suckers from infested soil to farmland free of the nematode. To be quite sure that sets are free of the nematode, trim off any discoloured tissue with a knife. Then dip the sets in hot water (53°C to 55°C) for 20 minutes.

FURTHER INFORMATION

For further information about nematode diseases, contact the Chief Plant Pathologist, Plant Pathology Section, D.P.I., P O Box 417, Konedobu.

Copies of this Plant Pathology Note and of others in the series can be obtained from: Publications Sections, D.P.I., P.O. Box 417, Konedobu.

D.P.I. HORTCULTURE NOTE: NO. 10

CARROTS

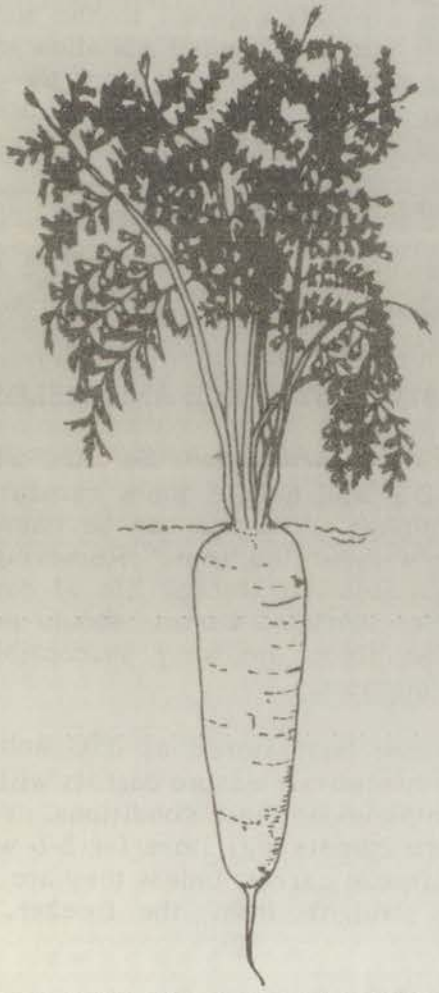
By P.B. Bull*, Senior Horticulturist, D.P.I., Laloki

Common Name: CARROT

Botanical Name: *Daucus carota*

WHAT THE PLANT LOOKS LIKE

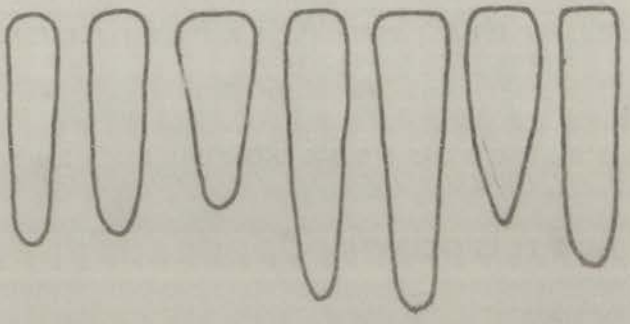
Carrots are grown for their long orange roots. These roots can grow up to 25 cm long and they vary in shape. The leaves are light green, feathery and look a bit like ferns. They have a similar smell to the leaves of Oenanthe (Tok Pisin: Nase).



A carrot plant, showing root and leaves

WHERE IT GROWS

The best quality carrots, those with long, deep orange-coloured roots, are produced when the maximum soil temperature is less than 24°C. When the maximum soil temperature is between 24 and 30° carrots still grow, but the roots are short, and pale yellow in colour. In Papua New Guinea carrots grow better above an altitude of 700 m. Carrots are frost resistant.



Shapes of carrot roots, one third natural size.

SOILS AND FERTILIZER

Carrots grow best in light, sandy, loam or pumice soils. A good content of organic matter is needed to give a good bright colour. The organic matter should be well broken down.

Carrot seeds are very small and they germinate best when sown very shallow in these light soils. Because carrot seedlings are quite weak, they do not grow well in silty or heavy soils which form a crust over

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* *Present address: Yates Research, P.O. Box 587, Pukekohe, New Zealand.*

the germinating seedling. Also, in light soils, the roots grow longer and more evenly.

Soil pH should be between 5.5 and 6.8.

In new gardens, fertilizer will not be needed for carrots. On ground that has been cropped before, apply 25 kg of nitrogen and 25 kg of phosphorous per hectare. This is obtained from an application of 50 kg urea plus 125 kg trifos per ha, before sowing.

Do not use fresh animal manure on carrots, because it causes the roots to fork.

VARIETIES

The recommended variety for lower altitudes is:

New Kuroda (Takii)

Popular varieties in the highlands include:

Manchester Table (Yates, N.Z.)
Topweight (Yates, N.Z.)
Western Red (Yates, Australia)

Other varieties are also grown.

HOW IT IS GROWN

Seed

To sow 0.1 ha with carrots, you need 200 g of seed. Carrot seed is available from local shops.

Sowing

Seed is sown directly into the field, either with a seed drill or by hand. If a seed drill is used, make sure that the correct setting for carrot seed is used. If the seed is sown by hand you can mix it with sand. This helps prevent sowing it too thickly. Seeds should be covered with fine soil to a depth of 1 to 1.5 cm.

Planting and spacing

Prepare beds 1.5 to 1.7 m wide. Sow three rows 50 cm apart on a bed. Closer row spacings can be used if mechanical or chemical methods are available for weed control.

Thinning

If the seed has been sown too thickly by hand, the plants may need thinning out when they are about 5 cm high. Thin to about 3 cm between plants in the row.

Irrigation

In dry areas or seasons, irrigation every two days is needed for good germination. Once the crop is growing it should be watered every week.

Weeding

Carrot seedlings grow slowly, so the crop should be weeded regularly, especially during the early stages of growth.

With some varieties, the shoulders of the carrots grow out of the ground. If the shoulders are left exposed to the sunlight they turn green. If you put a shallow mound of soil along the row during the final weeding, this will keep the roots all orange.

TIME TO MATURITY

From sowing, carrots take from 10 to 15 weeks until they are ready for harvest.

HARVESTING, STORAGE AND YIELDS

The mature carrots can be dug with a fork. Dig and handle them carefully to avoid damage. Carrots can be harvested with or without the tops. Removing the tops increases the storage life of carrots. Bruised or damaged carrots should not be stored as these are very susceptible to storage diseases.

Carrots are best stored at $0^{o}C$ and high relative humidity. Mature carrots will keep 3-4 months under these conditions. Young, immature carrots will store for 3-6 weeks. Do not freeze carrots unless they are to be cooked straight from the freezer. The

carrots should first be 'blanched', - that is partly cooked by boiling for 2 minutes, - then cooled quickly in iced water, before freezing. The higher the temperature in the freezer, the shorter the storage life.

Carrot yields range between 5 tonnes per ha to 30 tonnes per ha.

HOW CARROTS ARE USED

Both the leaves and the roots of carrots can be eaten, but it is the roots that are marketed. The roots are very rich in Vitamin A. They are best eaten raw, but can also be cooked. Cook until soft to bite - about 10 mins boiling. Do not overcook. Carrots taste good chopped up in a meat stew.

INSECT PESTS

Cutworm (*Agrotis ipsilon*) sometimes causes damage. (See Entomology Bulletin: No. 7).

DISEASES

Alternaria leaf blight causes the plants to lose their leaves, particularly under hot humid conditions. To control this disease, spray with 20 - 25 g of Copper oxychloride in 10 litres water. As the disease can be carried in the soil, do not plant carrots on ground which has previously grown carrots. Some varieties, for example, Topweight, are more tolerant of this disease.

Bacterial soft rot will infect carrots, particularly in poorly drained soils in the wet season. The best prevention is to plant on beds or on well drained soils. This disease is discussed in Plant Pathology Note No. 18.

Root knot nematodes cause galls (small lumps) on the roots of carrots. This pest is discussed in Plant Pathology Note No. 5.

FURTHER READING

Anon (1980). Plant Pathology Note No. 5. Root knot nematode. *Harvest* 6 (3): 154-156.

Farming Note No. 10. *Vegetables.* Department of Primary Industry, Port Moresby. Revised 1983.

Thistleton B. M. Recommendations for the Control of Pests. *Technical Report* 83/4, Department of Primary Industry, Port Moresby, 1983.

Tomlinson, D. (1982). Plant Pathology Note No. 18. Bacterial soft rot of vegetables. *Harvest* 8 (3): 141-144.

FURTHER INFORMATION

For further information and advice on fruit and vegetable growing, contact the Area Horticulturist in your region. The addresses for the Area Horticulturists are as follows:

New Guinea Islands Region
Lowlands Agricultural Experiment Station
P.O. Keravat, E.N.B.P.
Tel: 926251 or 926252

Momase Region
Bubia Agriculture Research Centre
P.O. Box 73, LAE
Tel: 424933

Papua Region
D.P.I. Laloki
P.O. Box 417, KONEDOBU
Tel: 281068

Highlands Region
Kuk Agricultural Research Station
P.O. Box 339, MOUNT HAGEN
Tel: 551377

Copies of this Horticulture Note can be obtained from: The Publications Officer, Publications Section, P.O. Box 417, KONEDOBU

CONTRIBUTIONS TO HARVEST

The aim of HARVEST is to help keep didimen and didimeris, teachers, research workers and other interested people informed about what is happening in primary industry all around Papua New Guinea.

If there is any work going on in your area which you think would be interesting to other HARVEST readers, we would be pleased to hear about it.

Articles can be about a single topic or project, the work of a group of people, or the primary industry of a particular area.

Articles should be presented simply and be fairly short (not more than about 3000 words, or 6 - 7 typed pages) with plenty of photographs or other illustrations, if possible. Black and white photographs give the best results. However, either colured prints or slides are acceptable alternatives. Line drawings can be redrawn in ink at Publications Section if necessary.

Two copies of each article, preferably typed with double spacing and wide margins, should be sent to the Editor at the address below. If you do not have access to a typewriter, hand-written articles are acceptable.

Send your articles to: The Editor, HARVEST, Publications Section, Department of Primary Industry, P O Box 417, Konedobu.

D.P.I. ENTOMOLOGY BULLETINS
PLANT PATHOLOGY NOTES
HORTICULTURE NOTES

All Entomology Bulletins, Plant Pathology Notes and Horticulture Notes which have appeared in HARVEST are available as reprints. They can be obtained by writing to: The Publications Officer, Publications Section, Department of Primary Industry, P.O. Box 417, KONEDOBU. (Telephone: 214699 ext. 386)

ENTOMOLOGY BULLETINS

1. Fumigation of stored products using methyl bromide
2. Control of termites in cocoa
3. Pests of cocoa - Trunk longicorns
4. Pests of cocoa - Use of crazy ants for control of *Pantorhytes*
5. Pests of cocoa - *Pantorhytes*
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15. The sorghum midge
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17. The sweet potato weevil
18. Occasional pests of sweet potato
19. Fruit flies
20. Insect pests of winged bean I. *Leucoptera* - a leaf miner
21. African armyworms
22. Bed bugs
23. Pests of cocoa - Mirids
24. Pests of cocoa - Grey weevils
25. Pests of cocoa - Leaf eating insects
26. Pests of cocoa - Mealybugs
27. A code of practice for hygiene in registered cocoa stores
28. The beanfly
29. Taro beetles
30. Oribius weevils
31. Pests of coconut palm - The Asiatic rhinoceros beetle
32. Pests of coconut palm - The New Guinea rhinoceros beetle
33. Green scale: A pest of coffee
34. Heliothis caterpillars
35. Heliothis caterpillars - a pest of sorghum
36. Pests of coconut palm - The black palm weevil
37. White wax scale: A pest of citrus
38. Buffalo fly
39. The human flea
40. Pests of cucurbits - 1. Pumpkin beetle
41. Pests of cucurbits - 2. Black leaf-footed bug
42. Pests of cucurbits - 3. Minor pests of cucurbits
43. Psyllid pest of leucaena
44. Human lice

PLANT PATHOLOGY NOTES

1. Blister smut of maize
2. Coffee rust disease
3. Collar rot
4. Rhizobium supply service
5. Root knot nematode
6. Black pod disease of cocoa

PLANT PATHOLOGY NOTES (continued)

7. South American leaf blight of rubber
8. Sweet potato little leaf
9. Taro blight
10. Fiji disease of sugar cane and its vector
11. A new treatment for bark canker on cocoa
12. The importance of quarantine against coffee rust in PNG
13. Virus diseases of taro
14. Ridomil tolerance
15. Bacterial wilt
16. Fungal diseases of tomato
17. Sweet potato leaf scab
18. Bacterial soft rot of vegetables
19. Citrus canker
20. Bark canker of cocoa
21. Vascular-streak dieback disease of cocoa
22. Seedling blight of cocoa
23. Brown eye spot disease of coffee
24. Bacterial head rot of banana
25. Rice blast
26. Nematodes - a threat to crop yield
27. Collar rot of aibika
28. Black rot and leaf scald of crucifers
29. Early and late leafspots of peanut
30. *Radopholus similis* - the burrowing nematode of banana

HORTICULTURE NOTES

1. Capsicums
2. Tomatoes
3. Cabbage
4. Yams
5. Chinese cabbage and pak choi
6. The giant Vietnam guava
7. Vegetable variety recommendations for the Port Moresby lowlands
8. Cassava
9. Vegetable variety recommendations for the highlands of Papua New Guinea
10. Carrots