PROCEEDINGS OF THE FIRST PAPUA NEW GUINEA FOOD AND NUTRITION CONFERENCE

Theme: Changes in Food and Nutrition in the Last Three Decades

Held at the National Sports Institute, Goroka from 31 October to 4 November 1983

Edited by

Malcolm P. Levett, Jane Earland and Peter Heywood

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ABBREVIATIONS

ADB  Asian Development Bank
AFTSEMU Agricultural Field Trials, Extension and Monitoring Unit
AgNutSP Agriculture and Nutrition Education Sub-Project (of ESRDP)
amsl  above mean sea level
ANU  Australian National University
ASSP Agricultural Support Services Project (of DPI)
ATDI Appropriate Technology Development Institute
AVRDC Asian Vegetable Research and Development Centre
B  Boron
BARC Bubia Agricultural Research Centre
BBA born before arrival
BF broiler finisher
CFM Central Food Marketing
CHFMC Central Highlands Food Marketing Corporation
CL cassava leaves (fresh)
CP crude protein
CSAPP Community Schools Agriculture Pilot Project
CSIRO Commonwealth Scientific and Industrial Research Organisation
CV coefficient of variation
DAP days after planting
DO day old
DPI Department of Primary Industry
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>DPS</td>
<td>Division of Primary Services</td>
</tr>
<tr>
<td>ESRDP</td>
<td>East Sepik Rural Development Project</td>
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<tr>
<td>F&amp;N</td>
<td>Food and Nutrition</td>
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<tr>
<td>FAD</td>
<td>fish aggregating device</td>
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<tr>
<td>FAO</td>
<td>Food and Agriculture Organization (of the United Nations)</td>
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<td>FMC</td>
<td>Food Marketing Corporation</td>
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<tr>
<td>FSR</td>
<td>farming systems research</td>
</tr>
<tr>
<td>FSR&amp;D</td>
<td>farming systems research and development</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
</tr>
<tr>
<td>H/A</td>
<td>height-for-age</td>
</tr>
<tr>
<td>IARC</td>
<td>International Agricultural Research Centre</td>
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<tr>
<td>IASER</td>
<td>Institute of Applied Social and Economic Research</td>
</tr>
<tr>
<td>IBPGR</td>
<td>International Board for Plant Genetic Resources</td>
</tr>
<tr>
<td>IBRD</td>
<td>International Bank for Rural Development</td>
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<tr>
<td>IITA</td>
<td>International Institute for Tropical Agriculture</td>
</tr>
<tr>
<td>IRD</td>
<td>Integrated Rural Development</td>
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<tr>
<td>IRDP</td>
<td>Integrated Rural Development Programme</td>
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<td>ISG</td>
<td>improved subsistence gardening</td>
</tr>
<tr>
<td>ISNAR</td>
<td>International Service for National Agricultural Research</td>
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<tr>
<td>ISTC</td>
<td>in-service training centre</td>
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<tr>
<td>K</td>
<td>Potassium</td>
</tr>
<tr>
<td>LAES</td>
<td>Lowlands Agricultural Experiment Station (Keravat)</td>
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<tr>
<td>LBW</td>
<td>low birth weight</td>
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<tr>
<td>LMU</td>
<td>land mapping unit</td>
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<tr>
<td>LPV</td>
<td>large pore volume (of soil)</td>
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<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>LSC</td>
<td>Land Suitability Class</td>
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<tr>
<td>LSI</td>
<td>Land Suitability Index</td>
</tr>
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<td>LSR</td>
<td>Land Suitability Rating</td>
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<tr>
<td>LUR</td>
<td>Land Use Requirement</td>
</tr>
<tr>
<td>LUT</td>
<td>Land Utilization Type</td>
</tr>
<tr>
<td>MAP</td>
<td>months after planting</td>
</tr>
<tr>
<td>MCH</td>
<td>Maternal and Child Health (clinic)</td>
</tr>
<tr>
<td>MF</td>
<td>mixed foliage (fresh)</td>
</tr>
<tr>
<td>N</td>
<td>Nitrogen</td>
</tr>
<tr>
<td>NFE</td>
<td>non-formal education</td>
</tr>
<tr>
<td>NIST</td>
<td>National In-Service Training</td>
</tr>
<tr>
<td>NNS</td>
<td>National Nutrition Survey</td>
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<tr>
<td>NPEP</td>
<td>National Public Expenditure Plan</td>
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<tr>
<td>NPO</td>
<td>National planning Office</td>
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<tr>
<td>OIC</td>
<td>Officer-in-charge</td>
</tr>
<tr>
<td>P</td>
<td>Phosphorus</td>
</tr>
<tr>
<td>PANEC</td>
<td>Provincial Agriculture and Nutrition Education Committee (East Sepik Province)</td>
</tr>
<tr>
<td>PNGRIS</td>
<td>Papua New Guinea Resource Information System</td>
</tr>
<tr>
<td>PRC</td>
<td>Poultry Research Centre (Labu, Lae)</td>
</tr>
<tr>
<td>RDA</td>
<td>recommended dietary allowance</td>
</tr>
<tr>
<td>RMU</td>
<td>Resource Mapping Unit</td>
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<tr>
<td>SPL</td>
<td>sweet potato leaves (fresh)</td>
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<tr>
<td>SSCEP</td>
<td>Secondary Schools Community Extension Project</td>
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<tr>
<td>SHRDP</td>
<td>Southern Highlands Rural Development Project</td>
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<tr>
<td>SHMA</td>
<td>Southern Highlands Management Authority</td>
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<tr>
<td>Acronym</td>
<td>Description</td>
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<tr>
<td>TIA</td>
<td>trypsin inhibitor activity</td>
</tr>
<tr>
<td>UN</td>
<td>United Nations</td>
</tr>
<tr>
<td>UNDP</td>
<td>United Nations Development Programme</td>
</tr>
<tr>
<td>UPNG</td>
<td>University of Papua New Guinea</td>
</tr>
<tr>
<td>UQ</td>
<td>University of Queensland (Brisbane, Australia)</td>
</tr>
<tr>
<td>USA</td>
<td>United States of America</td>
</tr>
<tr>
<td>VDC</td>
<td>Village Development Centre</td>
</tr>
<tr>
<td>VDCPP</td>
<td>Village Development Centre Pilot Project</td>
</tr>
<tr>
<td>VLEW</td>
<td>Village Level Extension Workers</td>
</tr>
<tr>
<td>W/A</td>
<td>weight-for-age</td>
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<tr>
<td>W/H</td>
<td>weight-for-height</td>
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FOREWORD

The First Papua New Guinea Food and Nutrition Conference, held in Goroka in Eastern Highlands Province from 31 October to 4 November 1983, was the third conference on food crops successfully staged by the Department of Primary Industry within a period of eight years. Earlier conferences were held in 1975 and 1980. Collaboration with nutritionists, for this third meeting, saw the name modified to reflect the wider scope of the conference. The new name has been retained in the title of the published proceedings as it better reflects the initiatives made to more closely link the two disciplines, although the structure of the conference, and the mix of papers finally published, is broadly similar to those of earlier meetings.

Despite a flourish of typing activity at the Goroka Sports Institute immediately after the conference, the proceedings were not compiled, and for several years it was uncertain that they would ever be published. Papers in various stages of completion, in hard copy and computer disk format, passed from desk to desk as a succession of well-intentioned editors left the Department of Primary Industry. In 1990, twenty five papers were salvaged from the deteriorating computer disks, and efforts made to contact those who presented papers yielded a further seven manuscripts.

Together, the 32 papers and the conference recommendations published here provide a substantial body of literature, too valuable to be left languishing on files. Many of the key papers presented at the conference are included, although it is possible that eight years after the conference a few of the papers originally offered for publication have still not been located. The editors have, however, combed the files and made considerable effort to contact conference participants to locate all available manuscripts. The collection of papers finally assembled represents a good cross-section of the subject material offered at the conference, although the nutrition section is under represented; a number of the oral presentations were not offered for publication.

The papers published in the proceedings are a useful record of the rate of change occurring in nutrition, food crops and livestock agriculture, processing and marketing, and rural development projects in Papua New Guinea, up to the time of the conference. They also provide a statement of the status of food and nutrition research as at 1983, and their publication may assist research programmes to build on existing knowledge, and avoid repeating earlier work. Many of the authors have expressed enthusiasm for the proceedings to be published, even after such a lengthy delay, and this has provided much of the impetus for the editors to complete the work. It is to be hoped that sufficient use can be made of the material to justify the considerable difficulties experienced in assembling the papers.

The editors would like to thank all those authors who offered manuscripts for publication and corrected proofs, and extend an apology to anyone who we missed who still has an unpublished conference paper. Many people worked with
dedicated enthusiasm to make the conference a success, and their names are mostly lost in the mists of time. An important prime organizer of the conference who deserves special mention is John McCoomb, then of Vudal Agriculture College. Without his efforts it is unlikely that the conference would have eventuated. Cartographers Vagi Raula and Vaigoli Bouauka of the Department of Geography, University of Papua New Guinea, prepared many of the diagrams for publication; their work and skills are gratefully acknowledged.

Malcolm P. Levett
Department of Geography, University of Papua New Guinea,
Port Moresby, October 1991
RECOMMENDATIONS OF THE FIRST PAPUA NEW GUINEA FOOD AND NUTRITION CONFERENCE

GENERAL

1. The Conference recommends the establishment of an inter-Departmental Working Group of the following composition:

   Department of Primary Industry
   Health (Nutrition)
   National Planning Office
   Institute of Applied Social and Economic Research
   Institute of Medical Research
   Department of Decentralisation
   Department of Youth, Women’s Affairs and Recreation

The specific tasks of the Working Group would be:

A. To implement the recommendations of the 1983 Food and Nutrition Conference.

B. To review the recommendations of the 1980 Food Crops Conference and where appropriate incorporate them with those of the 1983 Conference.
C. To evaluate the organization and management of the 1983 Conference and make recommendations for the next conference, preferably to be held before 1987.

RESEARCH

2. The Conference recommends that a National Research Advisory Committee be established to provide guidance on the research priorities and programmes to be developed by the Department of Primary Industry.

3. The Conference recommends that the working group referred to in Recommendation 1 above should carry out a review of the present Food and Nutrition Policy (1978) in the light of the results of the 1982-84 National Nutrition survey. In this way nutrition policies can be developed and food policies enacted which promote dietary changes associated with good health and discourage dietary changes associated with poor health.

4. The Conference recommends that future research related to food and nutrition should:

   A. Focus on the identification of geographic/provincial/ sub-provincial food and nutrition priorities.

   B. Form one of the priorities of the Agricultural Research food crops programme in relation to cash crops and economic development.
C. Focus on the more specific definition of various contributors to the human growth pattern: metabolic, biologic and sociologic.

D. Take account of the sampling frame established for the National Nutrition Survey (NNS 1982-84) to ensure comparability.

COORDINATION

5. The Conference recommends that

(a) the support of the recommendations of the Policy Recommendations of the UNDP Report on Subsistence Food Production, and

(b) the support of the recommendations of the projects for Phase I of the UNDP Report

be immediately translated into action.

6. The Conference recommends that Phase II of the UNDP Report be studied by the implementing agencies prior to submission to the National Executive Council.
EXTENSION

7. The Conference recognises the need for an upgrading of training in community-based extension/rural development in Papua New Guinea. The Conference recommends:

A. The establishment of inter-departmental induction training in community-based extension/rural development at the provincial level.

B. The establishment of inservice training in community-based extension/rural development.

8. The Conference recommends that every effort should be made to have extension and research staff work together, *i.e.* joint patrols, joint workshops/seminars, applied on-farm research.

9. The Conference recommends increased support for the post-harvest handling, storage, processing and marketing of fresh foods, to facilitate a viable fresh foods industry.
PART I:
FOOD & NUTRITION
POLICY
FOOD PRODUCTION AND NUTRITION - A POLICY PERSPECTIVE

Joel Noel

National Planning Office, Port Moresby

ABSTRACT

The present national policy on food production and nutrition has as its primary objectives (1) to reduce the country's dependency on imported foods, and (2) to improve the nutritional status of the population. The National Public Expenditure Plan has been the only avenue to implement the policy, and less than half the allocated funding ceiling has been utilised each year, due to a lack of suitable project proposals. There have been significant achievements in the past five years, particularly in relation to nutrition surveys, nutrition programmes, nutrition education and food processing research. However, much remains to be accomplished, and a thorough review of the funding procedures is necessary.

NATIONAL POLICY

The present policy on food production and nutrition has been in existence for the last five years. A review of the effectiveness of this policy is therefore necessary. For the purpose of this conference it would have been appropriate for the National Planning Office (NPO) to be presenting a complete review of the success or the effectiveness of implementing the basic recommendations of the policy. Since this is not possible, I will confine the discussion to the following: (1) the correct government policy; (2) some brief comments on its implementation; and (3) suggestions for a number of recommendations for future policy direction.

The policy is already known by many. Its primary objectives are to:

(a) reduce the country's dependency on imported foods; and

(b) improve the nutritional status of the population.

Under these two general objectives of the policy, the following targets for food production and nutrition were established:

(1) to increase domestic marketed production such that the volume of food imports remains at least constant over the next ten years;
to at least maintain subsistence production per head of the rural population, over the next ten years; and

(3) to improve nutrition significantly, by increasing food consumption per head to at least 90 per cent of recommended food energy requirements.

A number of specific recommendations were made to achieve these targets.

1. In the food production area it was recommended that the Department of Primary Industry (DPI) develop policies which emphasised the cost effective production of nutritious food.

2. It was recommended that production techniques which are more suited to market gardening be encouraged.

3. Suitable available land and interested groups were to be identified and helped with setting up commercial market gardening.

4. If necessary, non-nationals were to be allowed to produce foods also.

5. The now defunct government Food Marketing Corporation (FMC) was charged with the responsibility of market development, to ensure that local supply and imported foods are kept in reasonable balance.

It was further recommended that the Health Department direct research to detect the "at risk" groups while NPO would coordinate and monitor the performance of the overall Food and Nutrition (F&N) Policy. Departments such as Health, DPI, Transport, Lands, National Investment and Development Authority, and (formerly) Commerce were all to play a role in the implementation of this policy.

The National Public Expenditure Plan (NPEP) has been the only avenue for implementing the recommendations, at the national level. A review of this system indicates the following points.

A. There has been a general lack of viable import replacement NPEP projects coming from the implementing agencies. For example, the NPEP expenditure ceiling for the Food and Nutrition (F&N) Objective was 4.4 per cent in 1978-1979, 5 per cent in 1980 and 4 per cent in 1983.

B. Commitments of NPEP project funds under the F&N strategic objective for the 1981-1986 NPEP period has only been 1.6 per cent. In 1983 this dropped to 0.4 per cent.
The following is a list of reasons for this under-performance.

1. The recommendations of the policy are broad, and government departments have had some difficulties in interpreting the principles of the policy in terms of the strategic objectives, and thus in submitting appropriate projects.

2. There is a shortage of available, skilled manpower within the implementing agencies and provinces to identify and develop appropriate projects.

3. There appears to have been a lack of structural links between the various agencies and thus they have been unable to properly understand their roles, and how they are complementary or related to each other in meeting the objectives of the policy.

4. Although the defunct FMC was identified as being the agency responsible for developing marketing, not much was achieved during the life of the agency. Much of this failure was due to the fact that the FMC had an annual grant of only K500,000, with no forward commitment. The corporation, if it had been given a chance to operate independently as a commercial venture, might have achieved some of its objectives.

**ACHIEVEMENTS**

Certain aspects of the policy have been achieved. For example, the nutrition programme in the Department of Health is fairly well established, but to attain the overall benefits of this programme it needs to be linked to the development of domestic food production.

Nutrition education through schools has continued to be provided by the education department. Specific action has now been taken by government to limit the growth of food imports by placing import restrictions on eggs and on most vegetables which can be locally grown.

The DPI has set up a food processing and handling plant at the University of Technology, to ensure that research is carried out in developing appropriate methods of handling, processing and marketing. However, there is still much to be done in this area.

The 1982 National Nutrition Survey has been completed, and tentative results indicate that the "final results" will be able to identify the type and degree of most malnutrition in the country. Future nutrition intervention programmes may thus in future be based on more relevant and scientific data.
RECOMMENDATIONS

Although the government has continued to address the problems of food production and food requirements through the F&N policy, I can say that we in the NPO would be the first to admit that much still needs to be done and improved in this area. Our position is stated in three main points below.

1. Most of the recommendations of the Subsistence Food Production Planning Study are endorsed and supported by the NPO, in particular those which suggest that (a) Provincial Governments develop provincial policies on food and nutrition, and (b) coordination and management at the provincial and national levels be improved. We also support the recommendation that appropriate training of provincial staff is essential.

2. It is recommended that a full review of the NPEP be undertaken to assess the effectiveness of the policy in meeting its objectives. This review should include an examination of the fundamental recommendations, to reassess their viability and feasibility. This will enable us to see if we can take a different approach to this policy.

3. An assessment of the NPEP system as the only avenue for implementing the policy is required. We shall need to ask whether it has been effective, and if not then what alternatives are there for the implementation of the policy. This will provide us with sufficient information on whether the government should continue to be a ‘doer’ in food production and marketing, or whether it should act as a catalyst, facilitating and creating the necessary environment for the private sector to implement food production on a commercial basis.

In conclusion, I would like to emphasise that a review of the development direction of the F&N policy, in the light of the present economic and budgetary constraints of the economy, is essential and timely. In this way we could develop better guidelines for future resource allocation to food production and improved nutrition.
POLICY OPTIONS FOR FOOD PRODUCTION

B. Bai

Department of Primary Industry, Port Moresby

ABSTRACT

The changes that have affected people's eating habits over the past thirty years are briefly reviewed. Some of the food production and marketing problems encountered by the Department of Primary Industry are discussed. Six options which are available in relation to food production are presented. The widening gap between policy and implementation and the need for cooperation and collaboration are highlighted.

BRIEF REVIEW

The supply of food, its quality and its cost are matters which concern all thinking people. One of the Department of Primary Industry's major concerns is that people have enough to eat, and that the foods available are capable of providing a balanced diet. Good quality food is vital for a healthy population.

In keeping with the theme of this conference I would like to review briefly some of the changes that have affected eating habits in Papua New Guinea (PNG) during the last three decades.

Thirty years ago all but a very few Papua New Guineans lived in the traditional manner. They depended entirely on subsistence food gardens and, in some places, on hunting and gathering for their sustenance.

In terms of government agricultural services, it is perhaps interesting to note that the Department of Agriculture, Stock and Fisheries, as it was known in 1954, consisted of 54 officers stationed in New Guinea, 33 officers in Papua, a headquarters staff of 31, and 20 unattached officers, making a total staff of 138.

More and more people are depending on purchased foods: some because they no longer have access to a subsistence garden; others because they find packaged foods more convenient, easier to store, and quicker to prepare; and yet others because they prefer rice, tinned meat and fish, flour, sugar and other packaged foods, to the normal range of garden foods.

Regardless of whether this swing to processed foods is good or bad, from a nutritional or economic point of view, we would do well to acknowledge the fact that it is likely to continue.
It would seem, superficially at least, that the aims of today's Department of Primary Industry (DPI) are not all that different from those set down thirty years ago. It should be recognised that the demand for agricultural extension services over the years has been in the area of export crops. Subsistence gardeners have tended to adapt to changing circumstances, and have expanded production to allow food that is surplus to the needs of the family to be sold in local markets. The last census indicated that 53 per cent of all rural households derive some income from the sale of fresh foods.

The Administration prior to Independence recommended a cautionary approach to subsistence food gardening practices. It was recognised that there were many ways in which production efficiency might be increased, but it was also realised that in the long term these could contribute to the destruction of agricultural resources, and result in real food shortages.

The Administration's agricultural development plan in those days had three main aims:

1. improvement of the agricultural methods followed by indigenous people, with the aim of increasing the volume of production and nutritional level of the population;

2. the increase in production of certain commodities (e.g. rice, meat, dairy produce and certain fresh fruit and vegetables) which are at present imported; and

3. the increase in production of certain commodities for export (e.g. copra, rubber, cocoa, tea, coffee, kenaf, manila hemp, sisal and peanuts).

Much has happened since 1954. Papua New Guinea is now a self-governing independent nation. Its government and its people have assumed the responsibilities and problems that go with nationhood. A people who, thirty years ago, lived simple village lives now are obliged to face the complex challenges of modern-day existence. Yet some old problems linger on.

During recent years people have become increasingly mobile. They are no longer tied to the village in the same way that they were a generation ago. Urban growth is a fact of life and it will continue. Food production has assumed an increasingly important place in Papua New Guinea's development priorities during recent years.

Although Papua New Guinea produces the bulk of its food requirements from subsistence gardens, substantial quantities also come from other countries. Food imports amounted to 19 per cent of the value of all imports to Papua New Guinea in 1982. It is understandable therefore that agricultural self-sufficiency has been strongly promoted as a highly desirable objective.

Despite our best efforts to promote self-sufficiency, food imports have continued at a high level. However, there are indications that recent initiatives, for example the local production of sugar and the placement of import bans on poultry and
pork, are making an impact. In papers to be presented this week, these and other of the Department's programmes will be outlined.

The production of vegetables to meet the demand of rapidly expanding populations in urban centres, especially Port Moresby, is perhaps the most important problem facing DPI. It is also one of the most complex. The government has recently placed a partial ban on the import of fresh vegetables. The aim is to encourage local production. There are problems with this at present, but hopefully they will be overcome. We in DPI know that it is not a simple matter of producing more local vegetables. These vegetables must be of acceptable quality, produced on a continuous basis and affordable.

One consideration that does not receive sufficient attention is the question of affordability. We must find a way of producing staple food items at a cost which the bulk of the population can afford. Very simply, food producers must become better farmers. Market gardening is generally recognised as being one of the most complex forms of farming. If vegetables are to be produced at a price which the ordinary citizen can afford, the producer must learn to spread his profit over a greater volume of production.

One problem area which at this time defies solution is the marketing of vegetables. Central food markets have not been successful. Direct purchase of vegetables by retailers tends to create monopolistic situations which exclude the small scale producer, and the direct selling of vegetables in council markets by growers is time consuming and tends to perpetuate an excessive pricing system which is not in the interests of the consumer. Clearly a better marketing system is a key requirement to an orderly local fruit and vegetable industry.

There are tentative plans to establish a local rice industry and also meat, fish and vegetable canneries to produce local products capable of replacing major import items. During this conference attention will be focussed on these initiatives.

One very important decision needs to be made before final commitments can be made to establish these industries here. This relates to price. Is it really in Papua New Guinea's best interests to establish these industries if the processed product is going to cost more than the imported product, or if the local product is going to be of comparable cost but of inferior quality? This is a question which must be left to the politicians, but a decision is needed before we can proceed very much further with plans to develop food production.

**POLICY OPTIONS**

We need, at this stage, to identify the options available in relation to food production, and to select those best suited to our needs. The main options available appear to be as follows:

(1) we continue to import the bulk of our food requirements from overseas, clearly not an option which will meet with government approval, and one
which will leave Papua New Guinea susceptible to the effects of inflation in other countries, and vulnerable to disasters affecting the source of supply;

(2) regardless of cost and other problems, we develop local industries capable of producing all our food requirements and replacing all food imports;

(3) we encourage the production of selected food items best suited to our local conditions, and continue to import other items;

(4) we maximise the economic return from agriculture by promoting the production of those crops, both for export and for local consumption, which will give the best returns to land, labour and capital, and continue to import other food items;

(5) we do nothing and let the industry develop without interference; or

(6) we use DPI's resources to expand research into nutritional problems, and when these have been identified and solved we formulate policies to implement the solutions.

**DPI COMMITMENT**

The Government has recently commissioned the United Nations Development Programme (UNDP) to investigate subsistence food production. The consultants' findings will be discussed during this conference. Their recommendations include suggestions for a number of projects which will improve food supply. The report includes much statistical data relevant to this conference. The DPI is in the process of studying the consultants' report, and will in due course take appropriate action to implement those recommendations considered to be valid and appropriate. I would like to suggest that this conference studies these recommendations and provides comments which might help the government to make decisions in accord with food and nutrition interests.

I am aware of a widening gap between the policy and implementation areas. This is a matter of considerable concern. The DPI, and conferences such as this, may identify problems related to food and nutrition and produce recommendations designed to rectify these problems, but this will not achieve anything if the implementing authority is disinterested, or if it gives higher priority to other projects.

National DPI is able to plan and identify large scale projects of national importance, but one of the aspects emphasised strongly by the UNDP consultants is that most subsistence problems will have to be identified and solved at Provincial or District or even individual village level. Thus there is probably a need for a major extension effort at village level, to firstly monitor subsistence gardening, and then if appropriate introduce new crops and cultural techniques. The division of functions between National and Provincial Governments limits DPI's involvement in this area.
Although DPI is prepared to aid Provincial Divisions of Agriculture by providing assistance in a variety of ways, its capacity is limited. A ‘Support Services Project’ is soon to be implemented by DPI. It is designed to increase the Department’s capacity to give assistance, but it will take time to build up our capabilities because many of the problems are very complex. Also the Provincial Governments have ultimate authority in extension matters. Some Provinces are most cooperative and readily accept assistance; others, I regret to say, regard any sort of involvement by DPI as unwarranted intrusion.

If we are to correct all the problems relating to food and nutrition, we will need to have the fullest cooperation from all concerned. The DPI is ready to help in every way within its capacity, but it must be on a cooperative basis.

We recognise the role played by nutritionists and by others, such as school teachers, in this field, and we in no way wish to interfere in matters which are clearly their responsibility. However, we welcome suggestions and promise to give them our careful consideration.

In conclusion I would like to wish this conference success. I am pleased to see so many of my Department’s officers involved. I will be looking forward to your report and recommendations.
REORGANISATION OF THE DEPARTMENT OF PRIMARY INDUSTRY CROP RESEARCH SERVICE

A. E. Charles

*Department of Primary Industry, Port Moresby*

**ABSTRACT**

The present structure of the Agriculture Branch of the Department of Primary Industry is outlined. The role of the International Service for National Agricultural Research in developing guidelines for (1) meeting the training needs of agricultural scientists, and (2) a more effective research structure is briefly reviewed. The proposed new structures for an Agricultural Development Branch and a Crops Research Branch in the Department of Primary Industry are presented.

**INTRODUCTION**

This conference will be devoting much of its time to considering results of food crops research, and to problems of food and nutrition that need research. Probably most of you are aware that the Department of Primary Industry (DPI) crops research service is being reorganised. However, not much has been publicised about this, so it seems appropriate that I should outline what changes are planned, with particular emphasis on how they will affect the areas of food production and nutrition.

**THE NEED FOR REORGANISATION**

A brief background to the reorganisation is that it has resulted from both internal and external concerns. Internally, there was concern that the research service had been weakened by loss of experienced overseas scientists which had resulted in a lack of strong guidance and support needed to enable incoming national scientists to develop their research capabilities. An excessive administrative load on senior researchers hindered them from providing effective direction to the research activities. Also, liaison between the research and extension services was very weak.

Externally, the World Bank was concerned about stagnation or a decline in Papua New Guinea's commodity exports. A mission was sent in 1981 to examine DPI's ability to support the tree crop industries. Among many other recommendations, the mission recognised the need to improve research services. It noted some
additional points of weakness, including (1) a lack of adequate coordination of work by the different disciplines; (2) insufficient involvement of the research service in DPI policy formulation; and (3) too wide a spread of research activities without sufficient concentration on major priority areas. It recommended a research reorganisation, and also offered assistance to government to improve agricultural support services generally.

The DPI next asked the International Service for National Agricultural Research (ISNAR) to assist with a more detailed review of the research service, looking especially at (1) training needs of national scientists; (2) recommendations for food crops research; and (3) assisting in a more detailed way in devising a more effective research structure.

Since then, DPI has negotiated a World Bank loan for an 'Agricultural Support Services Project' (ASSP) in which support for training research scientists, and various measures to upgrade the research service, will receive K6.2 million over a four year period (33 per cent of the total loan).

THE CURRENT STRUCTURE

Turning now to the actual reorganisation, as the theme of this conference is "changes in the last three decades" I will start by describing the structure which existed for most of that period (see Figure 1).

The structure shown in the chart has not changed significantly during the period, except for the splitting of the Agronomy Section into an Agronomy Section and an Horticulture Section in 1976.

Before commenting on the strengths and weaknesses of the structure, let me make the point that the performance of any research service depends mainly on the creative ability of the individuals who work in it and not on its organisation. Nevertheless, the structure does have considerable influence on the type of research produced.

Three major weaknesses in the old structure are given below.

1. The Assistant Secretary (Agriculture) had to divide his attention between agricultural development projects and crops research. In recent years, the appointee has not been a researcher, and this has limited his ability both to make decisions relating to research and to represent the research viewpoint in Departmental policy discussions.

2. All section chiefs and station officers-in-charge had major administrative responsibilities as well as responsibility to oversee research. Especially on the larger stations, and for the larger sections like Agronomy and Horticulture, they had little time for directing research, and thus scientists were left largely to develop their own programmes.
Figure 1. Present structure of Agriculture Branch, Department of Primary Industry.
3. The research tended to be strongly disciplinary. As a result, researchers seldom looked at crop improvement from all aspects in order to develop overall priorities. Also, since a section was often represented by only one person at one location, a junior scientist might have had no one in his own discipline to supervise him, and researchers in other disciplines did not see it as their responsibility.

The third point has also had some important strengths in the past, at least at those times when the research stations have been well staffed with competent scientists. The disciplinary sections have formed strong teams which have made major contributions to solving production problems in their discipline.

THE PROPOSED NEW STRUCTURE

Turning to the new organisation, the main features are shown in Figure 2 and Figure 3. The following are some comments on the changes, and their purpose.

Firstly, research and development are separated, each being led at Assistant Secretary level, and are thus both represented in the Department’s Policy Group. This doubles the "crops" representation, in line with the dominant place of crops in Papua New Guinea primary industry. However, the two branches will retain close links. The Land Utilisation and Agricultural Chemistry Sections, although placed in the development branch because of their role in the preparation of development projects, are primarily concerned with the provision of professional services, and could equally well be in the research branch. It is to be hoped that it will never be forgotten that the justification for research is that it stimulates agricultural development.

In relation to food and nutrition, an important change is the establishment of a Horticultural Projects Section in the development branch. This will take over from the present Horticulture Section all development activities, such as the seed potato project, and will plan and organise new activities in the food production area.

More details of the research branch are shown in Figure 3. Some of the major features are considered below.

1. The Research Director will be responsible for directing a service which will provide technical advice to (1) Government, to aid sound planning for agricultural development; and (2) to producers, to assist them in efficient and profitable farming. He will ensure the development of a team of scientists who will be technical experts in crop production. He will also be responsible for ensuring close liaison between research and extension, and for coordinating nationwide agricultural research activities.
Figure 2. Division of Agriculture Branch under new structure.
A. Research direction and services

Director

Deputy Director

Station OICs    Research Teams    Pathology    Programming and Biometrics    Chemistry    Land Utilisation

B. Administrative organisation

Director

Chief, Research Administration and Administrative Cell

Station OICs

Deputy Director

Research Teams and Support Staff

Chief Plant Protection Officer

Entomology and Plant Pathology

Staff Development Officer

Research Programming and Biometrics

Figure 3. Organisational structure of new Research Branch.
2. A strong administrative unit at headquarters, and separate ‘Officer-in-Charge’ and ‘Team Leader’ positions on the stations, will reduce administrative responsibilities of research leaders and permit greater emphasis on the main research role. However, research administrators will be Scientific Officers, not simply managers, as it is essential that they be fully aware of and involved in the research activities for which the Branch exists.

3. There will be emphasis on team work at all levels. Problems such as pests or diseases will not be looked at in isolation by one specialist, but in association with other aspects of crop growth and production, including social and economic factors.

4. The strength of the research stations will be increased by establishing highly experienced researchers as team leaders able to concentrate fully on directing research, with administration and farm management handled by the officer-in-charge (OIC). Stations will be able to have a large measure of autonomy, with headquarters providing coordination and services.

5. Headquarters will be responsible for developing research policies in line with national priorities, communicating research findings and technical information to planners and politicians, providing centralised services in training, pest and disease identification, data analysis, library, publications, chemical analyses and land use evaluations.

6. Research teams will be multi-disciplinary, providing a substantial team of scientists to develop a concerted programme for improvement of the major food and cash crops. Initially there will be four main teams and two subsidiary teams, probably as given below, but yet to be finalised.

A. A highlands food crop team, based at Kuk Agricultural Research Station, concentrating on sweet potato improvement within the traditional farming systems. A subsidiary team at the Laloki Plant Quarantine and Horticultural Research Station will extend this work to lowlands sweet potato improvement.

B. A lowlands food crops team, based at Bubia Agricultural Research Centre if additional land can be obtained, concentrating on other lowland staples. A subsidiary team at the Lowlands Agricultural Experiment Station (LAES) at Keravat will study the particular needs of food crops in association with cocoa and coconuts.

C. A cocoa-coconut research team based at LAES Keravat, carrying out a research programme in cooperation with scientists funded by the Papua New Guinea Cocoa Industry Board.

D. A coffee research team, based probably at Aiyura, carrying out a research programme in cooperation with scientists funded by the Papua New Guinea Coffee Industry Board.
7. Research teams will include an economist who will look at economic aspects of production, with special emphasis on studies of village production systems, and an extension liaison specialist. Teams will give priority to developing effective two way communication with extension services and village farmers to ensure the relevance of research undertaken. When new technologies have been developed, ad hoc teams with appropriate skills will evaluate the technology under village conditions and devise effective ways of communicating them to farmers. Adaptive testing by provincial extension staff will be encouraged on a cooperative basis.

8. Crops not handled by the main teams will be supported, where possible, by an experienced researcher who will interpret world knowledge for local needs, and conduct limited adaptive trials. There are not enough resources available to tackle every agricultural problem, so priority must be given to those of greatest importance on a nationwide basis.

9. Research programmes will be reviewed annually and modified as necessary in the light of progress made and current priorities. The system has not yet been fully determined, but the aim will be to hold discussions between several research disciplines and representatives of producers and extension staff before it is finalised and submitted to headquarters for policy approval and funding. Approved programmes will be made public so that all those affected will be aware of what work is being undertaken.

**TIMING**

In terms of timing, the reorganisation involves many changes and will take some time to implement. Initial priority is being given to establishing the main highlands food crops research team and its lowland component at Laloki, and to developing cash crops programmes in association with the Papua New Guinea Cocoa and Coffee Industry Boards. Cocoa researchers at LAES Keravat have already prepared a basic document on the state of the cocoa industry, its research needs, and a programme for the coming year.

It is hoped that the highlands food crops team will become operational in 1984 and the lowlands team in 1985. Supporting services at headquarters will also be upgraded in 1984 and these will improve the efficiency of the field teams.

**IMPLICATIONS**

Let us now consider what this means for food and nutrition in Papua New Guinea. Firstly, we will be directing more resources to food crops studies, and such studies will be more concentrated. This will improve the quantity and quality of research, leading to a better understanding of the agricultural aspects of our major food crops and their production systems. A sound basis on which to identify problems, and develop new technology, that not only works but is adapted to the needs and desires of the producers will thus be provided.
Secondly, the programmes will be better publicised, leading to a better understanding of what the research service can and cannot do, thus making it a much more effective resource to assist in food and nutrition development programmes and projects at all levels of the nation and community.
PART II:

FARMING SYSTEMS
Most of the soils are colluvial and are characterised by a deep dark topsoil with a strong granular structure (loam to clay loam texture) merging into a grey clayey subsoil. These soils are known as "poreramaka". The flats are dissected by smaller areas of drainage depression. These soils are deep clays, very poorly drained, and very high in organic matter. They are known as "aramaka". The dominant vegetation is Phragmites cane grass.

The steep slopes (10 to 30 degrees) range from 1600 masl to about 1750 masl. They are vegetated by tall grasses (especially Miscanthus spp.) and some woody regrowth. Soil depth is generally thin because of previous soil erosion. The ridge tops and adjacent areas (1750 masl to 1985 masl) are covered by forest. The slope soils consist of a thin yellowish brown clay loam (0-20 cm) overlying a yellowish brown clay. They are known as "kakimaka," or as "makomaka" if they contain iron and manganese concretions.

The villagers are horticulturalists dependent on sweet potato (Ipomoea batatas) as their staple food. Major supplementary foods are Xanthosoma and Colocasia taro, bananas, highland "pitpit" (Setaria palmifolia), sugarcane, various leafy green vegetables, peanuts (Arachis hypogaea), maize and winged beans (Psophocarpus tetragonolobus). A list of the cultivated and self-sown food species and information on the crops' relative importance is given in the Appendix. Domesticated pigs are important social and dietary items. There is no long term pig cycle comparable to that practised in the western part of the central highlands region. Imported food, especially rice, flour, tinned fish and meat, biscuits, dripping and beer are now consumed in significant quantities.

**CHANGING CROP BASE**

The agricultural crop base has not been static in PNG, and crops vary greatly in their antiquity (Bourke 1990). A number of crops reached the country as a result of European exploration in the Americas, but before European settlement in PNG, and a large number of species has been introduced since European settlement, some of which have become major food items.

Tobacco (Nicotiana tabacum) is a crop of American origin that had diffused to New Guinea by about 1600 AD (Feinhandler et al. 1979) and was well established in PNG by the time of permanent European settlement (1870 onwards). Villagers say that the narrow leaf form (brus in Melanesian Pidgin) is a very ancient crop, but that the larger leaf type (tabak in Melanesian Pidgin) is a post-European introduction. Watson (1967) reported that, in the Kainantu area generally, numerous informants in the 1960s remember when they did not have tobacco. The discrepancies between the Asiranka data and Watson's account may have been brought about by Watson asking about the origin of "tabak" rather than "brus", the former being a specific form for post-European tobacco.

Maize (Zea mays) is said by older Asiranka people to have arrived before contact with Finschhafen missionaries or Europeans. It was obtained from Kamano speakers, most likely between 1922 and 1927. The traditional type is said to be red-grained, but it was held by only a limited number of people. It became a more
important food after European settlement, and by the early 1950s Schindler recorded that significant areas of maize were being grown. Watson (1967) recorded that maize was a pre-European crop in the Kainantu area, but that some men said that it was unknown to their ancestors. He suggested that it may possibly have reached Kainantu area much later than tobacco had done.

Cassava (*Manihot esculenta*) is another American species that may have been grown in PNG before European settlement. Watson recorded cassava as a pre-European crop in the Kainantu area. It is a minor crop at Asiranka where it is considered to be a post-European introduction. Cucumber (*Cucumis sativus*) is a pre-European crop at Asiranka, as it is in most of PNG, although it is often assumed by outsiders to be a recent introduction.

A large number of introduced species have been adopted as food plants by the Asiranka people. These include peanuts, *Xanthosoma* taro, potato (*Solanum tuberosum*), common beans (*Phaseolus vulgaris*), cabbage (*Brassica oleracea*), pak choi (*Brassica chinensis*), pumpkin (*Cucurbita moschata*), spring onion (*Allium cepa*), choko (*Sechium edule*), peas (*Pisum sativum*) and *Amaranthus caudatus*. Recently introduced fruit species that are grown and eaten include mandarin (*Citrus reticulata*), orange (*C. sinensis*), avocado (*Persea americana*), passionfruit (*Passiflora edulis* f. *edulis* and *P. lingularis*), pineapple (*Ananas comosus*), tree tomato (*Cyphomandra betacea*), and pawpaw (*Carica papaya*). Other introduced vegetables such as lettuce, capsicum and broccoli, are grown mainly for sale to expatriates (see Appendix).

Of the recently introduced foods, peanuts are now the most important and occupy an area second only to sweet potato (Table 5). People say that peanuts were introduced by the Seventh Day Adventist missionaries in the 1930s. Schindler (1952) estimated that by 1951 peanuts occupied some eight per cent of the area planted, for two families studied in the village. Most of the crop grown now is consumed within the village. *Xanthosoma* taro was another crop that was rapidly adopted following its introduction in the 1930s. By 1951 Schindler (1952) recorded it as major crop in the forest gardens. *Phaseolus* beans were introduced in the 1930s and were becoming popular by 1943 (McAdam 1943). They are now grown in significant quantities in sweet potato and mixed vegetable gardens for subsistence consumption and sale.

Despite the changes over the past 50 years, there is a continuity in the crop and animal base of subsistence agriculture, with sweet potato and pigs dominant throughout the period. For example, in 1951 Schindler (1952) recorded that sweet potato occupied 55 per cent of the garden area of two families, an almost identical figure to that recorded for 10 women by this author (57 per cent, Table 5). Many of the traditional supplementary foods are still very important, including *Colocasia* taro, winged bean, highland pitpit, bananas, sugarcane, *Oenanthe javanica* and *Rungia klossii*. 
### Table 5. Crops planted during a 36 month survey period (January 1980 to December 1982) by 10 women\(^1\) of Asiranka Village.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Garden area planted (m(^2)/woman/year)</th>
<th>Percentage of garden area planted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweet potato</td>
<td>2135</td>
<td>56.9</td>
</tr>
<tr>
<td>Mixed gardens(^2)</td>
<td>657</td>
<td>17.5</td>
</tr>
<tr>
<td>Peanuts</td>
<td>582</td>
<td>15.5</td>
</tr>
<tr>
<td>Winged bean</td>
<td>167</td>
<td>4.4</td>
</tr>
<tr>
<td>Introduced vegetables(^3)</td>
<td>78</td>
<td>2.1</td>
</tr>
<tr>
<td>Potato</td>
<td>67</td>
<td>1.8</td>
</tr>
<tr>
<td>\textit{Xanthosoma} taro(^3)</td>
<td>45</td>
<td>1.2</td>
</tr>
<tr>
<td>\textit{Colocasia} taro(^3)</td>
<td>16</td>
<td>0.4</td>
</tr>
<tr>
<td>Yams (\textit{Dioscorea} spp.)</td>
<td>4</td>
<td>0.1</td>
</tr>
<tr>
<td>Others(^4)</td>
<td>4</td>
<td>0.1</td>
</tr>
<tr>
<td>Coffee(^5)</td>
<td>(60)</td>
<td>(1.6)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>3755</td>
<td>100</td>
</tr>
</tbody>
</table>

\(^1\) The ten women surveyed supported ten other adults (8 husbands, 2 aged parents) and 25 resident children (mean 4.5 persons/woman). Thus to obtain mean garden area planted per person divide by 4.5. The gardens also fed 52-53 pigs (excluding young piglets) during the period of 1980 to early 1982.

\(^2\) Mixed gardens planted to numerous species in a mixed planting arrangement. Crops grown include \textit{Colocasia} taro, highland pitpit (\textit{Setaria palmifolia}), bananas, sugarcane, \textit{Phaseolus} beans, \textit{Oenanthe javanica}, \textit{Rungia klossii}, pak choi (\textit{Brassica chinensis}), maize, \textit{Nasturtium} schlecteri, pumpkin (\textit{Cucurbita moschata}), cucumber (\textit{Cucumis sativus}), \textit{Cyanotis} moluccana, tobacco, cabbage (\textit{Brassica} oleracea), \textit{Amaranthus} spp., peas (\textit{Pisum sativum}), spring onion (\textit{Allium cepa}), lowland pitpit (\textit{Saccharum edule}), ginger (\textit{Zingiber officinale}), \textit{aibika} (\textit{Abelmoschus manihot}) and choko (\textit{Sechium edule}).

\(^3\) Areas of predominantly these crops and do not include plantings in other garden types.

\(^4\) Strawberries, pineapple, maize grown in pure stands.

\(^5\) All new coffee plantings were interplanted with food crops, and the area has been included under the interplanted food crop.
CHANGING LAND USE PATTERNS

1930s to 1942

Prior to contact with outsiders, the people lived south-east of the Aiyura Basin in the Amomonta area. Gardens are said to have been located on both the slope soils ("kakimaka") and the colluvial soils ("poreramaka"). After contact with outsiders, which was mainly with Finschhafen evangelists at first, people moved to a number of sites in the Aiyura Basin during the 1930s. When the agricultural station was established in 1937, people were living at Onamunta, which is at the base of the steep slopes in the basin (Figure 2). Again gardens were located on both the slope soils and the colluvial soils (Table 6).

The major garden type in both environments was sweet potato gardens with most other food crops mixed planted in these gardens. Yams (Dioscorea alata and D. bulbifera) and winged beans were planted in separate sections of the sweet potato gardens. Mixed vegetable gardens were sometimes planted in swampy drainage depressions. Villagers nowadays say that up to four or five crops of sweet potato were planted and harvested on the same plot before it was abandoned to fallow. However, it is more likely that land was rarely planted to a second crop before fallowing on the slope soils6. Only one planting was made in the mixed vegetable gardens. People say that common fences (to exclude pigs) enclosed groups of gardens owned by different families.

Subsistence agriculture in the 1930s-1942 period appears to have been characterised by low intensity (low cropping : fallow period ratio) gardening, in both the short grasslands and on the woody regrowth/cane grass slopes. The major elements present in the late 1970s and early 1980s, such as drainage of swampy depressions to make mixed gardens, a winged bean/sweet potato rotation and the use of both short grasslands and regrowth areas, were present at this earlier period, although their importance differed from the later years.

1942 to 1945

This period was one of trauma and change for the villagers. Informants from the village say that four people were shot dead, probably sometime in mid-1942. The village was destroyed and people fled to other villages outside the Aiyura Basin. Later on, another five people who had fled were shot dead by police near Ontenu Village7. The Aiyura area was bombed and strafed by Japanese aircraft during May and June 1943.

The people lived in the forest area and in the villages during this period. Aerial photographs (22,000 ft) taken in September 1943 confirm this. There were no houses at Onamunta or Asiranka. The only garden was at the Asiranka site. From the middle of 1944 to the end of 1945, the villagers moved to a new site at Asiranka where the main village is now located8. People then changed to using family houses from the traditional separate men, and women and children housing pattern.
1946 to mid-1982

This period is characterised by a build up in intensity of land use and agriculture in the grasslands. After the move to the site at Asiranka, gardens were made initially on the slope soils near the village in cane grass and regrowth. Gardening was progressively extended onto the colluvial soils. By the time Schindler (1952) described the villagers' agriculture in 1951, 85 per cent of the gardens were in the grassland flats (Table 6). Very few gardens were made in the forest until the late 1970s. After the return of Government land to the villagers in 1976, a few of the more energetic gardeners returned to the forest, so that over the period 1980 to mid-1982, some 12 per cent of new gardens were planted in the forest area (Table 6).

Table 6. Location of food crop gardens (as a percentage of total garden area), for six different periods, Asiranka Village.

<table>
<thead>
<tr>
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<th></th>
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</thead>
<tbody>
<tr>
<td>Grassland flats</td>
<td>40</td>
<td>85</td>
<td>86(^1)</td>
<td>50(^2)</td>
<td>20</td>
<td>93</td>
</tr>
<tr>
<td>Forest area</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(forest fallow)</td>
<td>10</td>
<td>15</td>
<td>11</td>
<td>48</td>
<td>40</td>
<td>37</td>
</tr>
<tr>
<td>Forest area</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(grassland</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>fallow)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scrub regrowth</td>
<td>50</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>25</td>
<td>40</td>
</tr>
<tr>
<td>(steep slopes)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>


\(^1\)Plots of sweet potato, peanuts, winged bean, potato and yams on the better drained colluvial fans accounted for 84 per cent of these plantings. The remaining 16 per cent were mixed vegetable gardens, introduced vegetables, and *Colocasia* and *Xanthosoma* taro plots in the wetter drainage depressions.

\(^2\)Of this total, 75 per cent were on colluvial fans and 25 per cent were in the drainage depressions.

\(^3\)Eighty eight per cent were on colluvial fans, 12 per cent were in the drainage depressions.
The major change in land use during this period was drainage of the swamps and extension of cultivation into the drained land, mainly since 1960. A main drain was built through the bottom of the basin in 1945 by the agricultural station workers. Asiranka and Anamunapa people combined to build a smaller drain that better drained village land, sometime before 1956. There was an increase in the use of swampy areas for mixed vegetable gardens on sites that were too wet for sweet potato.

Another important change was the increasing intensity of land use. Over the period 1946 to 1951 the grassland sweet potato gardens were cropped for three years or more (Schindler 1952). By the early 1980s, some of these gardens commonly remained in production for 8-10 years. According to the villagers, the use of a peanut/sweet potato rotation facilitated this increased intensity. The peanut/sweet potato rotation has supplemented the traditional winged bean/sweet potato rotation practised in the grassland soils. A more recent innovation, since 1970, is the rotation of sweet potato and potato in the sweet potato gardens.

During the first part of this period, gardens were individually fenced. Schindler's (1952) description corroborates the villagers' account of fencing: "... the picture is presented of islands of fences scattered over the landscape". With increasing intensity of land use on the grassland flats, a common fence was erected to enclose the entire garden area of Asiranka. This was done between 1951 and the end of 1956 (when the CAJ aerial photographs were taken). In the early 1960s, a common fence 2.5 km long was erected that enclosed all of the garden land of the Asiranka and Anamunapa people. This remained in service until 1982.

Other changes during this period were the demise of hunting of tree kangaroos, opossums, wallabies, birds and rats, and the advent of coffee and market gardening as cash crops. Until 1951 (and probably later) people hunted mammals and birds in the forest and rats in the grasslands (Schindler 1952). By the late 1970s, hunting and trapping had declined to a minor activity because of the availability of tinned meat and fish, and because of stories about the dangers of eating rats, which were promoted by missionaries.

The first village coffee was planted early in 1949 in a communal block. Individually owned coffee plots were planted soon afterwards. Coffee has increased in importance to become the major cash crop. Opportunities for selling fresh food to outsiders arose soon after the agricultural station was established. During the 1960s and 1970s the market for introduced vegetables and fruit expanded rapidly because of the large number of expatriates living in the basin. People responded by planting the desired crops for marketing. By 1981-82, annual sales of fresh food at the Ukarumpa market in the Aiyura Basin were valued at K30,000. Most of this money went to residents of the basin, including Asiranka people (Bourke and Nema 1985). By 1978 people from the original Asiranka hamlet had formed five hamlets. In 1978 they formed a further two hamlets.

Village agriculture over the period 1980 to mid-1982 was characterised by a large number of crop species with sweet potato (57 per cent of garden area planted), the mixed vegetable gardens containing numerous species (17.5 per cent), peanuts (15.5 per cent), and winged bean (4.4 per cent) accounting for almost 95 per cent
of all plantings (Table 5). The most important garden type was the sweet potato garden in the grasslands. In these gardens, the soil was always tilled completely; drains were dug 4-8 m apart up and down the slope, and small mounds 30 cm high were made.

When land was first opened up after fallow, species demanding high fertility conditions were interplanted with the sweet potato. These included Phaseolus beans, maize, pak choi and Nasturtium schlechteri. As the fertility declined due to cropping, these species were excluded. Soil fertility was enhanced by a peanut or winged bean rotation. Winged beans were planted seasonally (May-August) and were managed for tuber rather than bean production. Measurements of sweet potato yields from 729 small plots over a 12 month period indicated a mean yield of 14 t/ha. Sixteen sweet potato cultivars were grown, nine of which were available prior to European contact.

Swampy depressions were used for mixed vegetable gardens containing numerous food species. Most of these gardens were planted at the end of the dry period (September to December). After clearing fallow vegetation (mostly Phragmites cane grass), the depressions were drained and then planted to a mixture of species with minimal soil tillage. In the cropping system, space initially occupied by short term crops, such as pak choi and amaranthus, was later taken over by the slower growing crops, such as taro and sugarcane. After the initial period of planting, no replanting of food crops occurred before fallowing.

Most new coffee plantings made since 1970 have been made in these drainage depressions in the mixed gardens. Initially shade for coffee seedlings is provided by taller food crops, such as bananas, maize and sugarcane. Seedlings of Casuarina oligodon are planted at the same time as the coffee or later. As the other food crops die out, bananas take over as the predominant shade for coffee, and are supplemented (and eventually replaced) by the casuarina. The households of the 10 women surveyed owned an average of 464 coffee trees per household in 1984 (95 per cent mature).

Only 12 per cent of new food garden plantings were made in the forested area between 1980 and mid-1982 (Table 6). These consisted of sweet potato gardens, made without mounding or complete soil tillage, and small areas of mixed vegetable gardens. A few gardens consisted of almost pure stands of Xanthosoma taro. Some winged beans were grown in rotation with sweet potato, but most gardens were planted to only one crop before fallowing.

The steep slopes between the forested ridge and grassland flats were used by only one of the women studied. She made a garden similar to the forest gardens, that is, a sweet potato garden mixed cropped with vegetables, with minimal soil tillage. A few minor areas of "household" gardens were also planted. Two of the ten women planted four sweet potato plots on land belonging to relatives at Ukarumpa Village, over the three year survey period. The ten women studied supported a total of 45 people and 52-53 pigs (excluding piglets younger than about two months of age), giving a pig:person ratio of 1.2:1. The pigs were excluded from the garden area in the bottom of the basin by the communal fence, and they roamed amongst the hamlets and on the steep slopes.
A number of perennial food crops were also grown. Fruit trees were planted around the hamlets, especially bananas, but also avocado, mandarins, passionfruit, tree tomato and other species. Nut pandanus (Pandanus julianettii) was cultivated in the forest above about 1700 masl. Highlands betel nut ("kavivi") (Areca macrocalyx) was planted in the bottom of the basin and in the forest. Marita (Pandanus conoideus) was planted in the lower parts of the basin near hamlets and in the drained drainage depressions, below 1630 masl. Mean numbers of fruit and nut trees owned per household for the ten households surveyed (in 1984) were 176 "karuka" (28 per cent mature), 137 "kavivi" (23 per cent mature), 19 "marita" (32 per cent mature), 5 avocados (35 per cent mature), and 1 immature mandarin tree.

There are now some 30 cattle owned by nine individuals. These are grazed in two fenced enclosures on land that was returned to the villagers from the agricultural station in 1976 (Figure 2). The grazed area is not used for food gardens. The fences are constructed from timber posts and barbed wire, and have not required major repairs so far.

Mid 1982-1983

In the latter half of 1982, there was a sudden withdrawal of gardening from the grassland flats which continued throughout 1983. There was a corresponding increase in gardening in the forest and scrubby regrowth areas (Table 6). The gardens that remained in the grasslands flats were either adjacent to the hamlets or the agricultural station and enclosed by an old government fence, or they were small plots enclosed by individual garden fences in the largely abandoned basin floor. After gardens were abandoned in the grassland flats, pigs were allowed to graze in the area from which they had been previously excluded.

Overall the intensity of cropping declined rapidly as people switched from the intensively used gardens to low intensity forest and regrowth gardens where the techniques of complete soil tillage, drainage and legume rotation were not used or were of only minor significance.

REASONS FOR CHANGE

Over the past 50 years, numerous changes have occurred in subsistence agriculture and land use of the Asiranka villagers. The two major changes were the move into the grassland flats (colluvial soils) after the Pacific War and the sudden withdrawal from this land type in 1982-83. What promoted these changes? It is tempting to attribute the move from the slope soils to the colluvial soils in 1944-45 to the introduction of steel tools, especially spades. Amongst the nearby Fore people, the introduction of the steel spade is said to have allowed a shift from forest to grassland gardening (Sorenson 1972). Schindler (1952, p 303) suggested that "the change to the steel axe, knife and spade can be regarded as an agricultural revolution." The villagers today, however, reject such an explanation. They insist that the move to the grassland flats was made possible because of the cessation of tribal fighting brought about by the Australian
administration during the 1930s. Prior to this, it was too dangerous to garden the flatter land where an enemy could easily escape detection.

Movement of gardening to lower alluvial soils, made possible by the cessation of tribal warfare, occurred elsewhere in the Kainantu area (Pataki-Schweizer 1980, p 20). In a nearby Tairora speaking village, the increased use of the wetter valley bottom for gardens after pacification is attributed by Grossman (1979, pp 214-216) to the cessation of warfare and the introduction of steel tools. In Asiranka, the traumas of 1943, that is, the killing of nine people, the destruction of the village, the Japanese air raids and the move to other locations, may have made people more susceptible to changes such as that in housing style and the conversion to more intensive grassland agriculture. The influence of the Australian administration and Lutheran Mission in encouraging people to move their hamlet locations is unknown, but this may have been a factor.

The changes that occurred between 1946 and mid-1982 are more amenable to explanation. The population was increasing rapidly (3.1 per cent per annum) and commercial production of coffee and vegetables commenced or expanded greatly. Drainage of the basin, firstly by the government (1945) and later by the people themselves, allowed a greater part of the bottom of the basin to be used. It also opened the way for greater use of the drainage depressions for mixed vegetable gardens and coffee. Production of supplementary crops in the specialised mixed vegetable gardens was necessitated as the intensity of sweet potato production increased. As this occurred and soil fertility was reduced, it was no longer possible to grow the supplementary crops with sweet potato and a second major garden type was developed. The reverse situation applied when agriculture disintensified after mid-1982.

For the 1982-1983 period, the immediate reason for the move away from the Basin floor was damage to gardens by domesticated pigs. Until then pigs had been excluded from the garden area by a single fence 2.5 km long that enclosed the entire grassland flats. By 1982 individual men were no longer prepared to maintain their sections of the communal fence. I heard complaints about pig damage from late 1980 onwards. The pigs belonged to both Anamunapa and Asiranka people, but it was claimed that the neighbouring Anamunapa pigs did most damage at first. This intensified during the first half of 1982. A crisis was reached in July of that year when virtually no new gardens were planted that month because of pig damage. From August, people relocated their gardens out of the basin floor and returned to the forest or regrowth. Land was opened up that had not been used since the mid-1940s.

There were two other less important reasons. Rascals ("raskals") had been attacking the village and stealing food. Both villagers and outsiders in the Aiyura Basin reported a rapid increase in stealing during 1982 and 1983. The ten women I worked with owned a total of 52 and 53 pigs (excluding piglets younger than about two months) when censused in May 1980 and March 1982 respectively. By November 1983, pig numbers declined by 50 per cent to 25 pigs. The loss of pigs was attributed to slaughter because they had damaged other people's gardens (14 deaths), stealing by rascals (9 deaths), and the usual consumption at minor feasts (4 animals killed). A similar situation was reported in Barabuna Village by
Grossman (1979, pp 242-246; 1981 p 228). Between July 1976 and March 1977, the Barabuna pig herd declined by 43 per cent. The decline was largely due to slaughter of pigs by the owners, to reduce the effects of a food shortage being experienced at the time.

The year 1982 had an unusual weather pattern. The early months were especially wet, and there were two periods of drought later in the year. However it was the effect of two frosts in July 1982 that was particularly significant. The frosts caused moderately severe damage to sweet potato, peanuts, corn, highland pitpit, banana, choko and winged bean in the grassland gardens on the flatter land. Production was not affected greatly, partly because of the already severe damage from pigs, but some people took the unprecedented frost as omen that they should move from the basin floor.

Extensive damage to food gardens by pigs, and to a lesser degree, a perceived problem with rascals and two unprecedented frosts were the immediate causes of the dramatic changes in the land use that occurred in 1982-1983. The distal causes are less obvious, however, and relate to the declining maintenance on the communal fence and increased lawlessness. The village councillor attempted to persuade people to repair the fence in the latter half of 1982 and early 1983, but without success. The community had lost its ability to resolve the problem of repairing the communal fence. The food supply crisis of 1982 resulted in a shift to a form of land use (individual family forest/slope gardens) that did not rely on community cooperation for maintenance.

By the 1970s, the villagers had been incorporated into the monetary economy. The three major sources of income were wage employment, sale of coffee, and sale of fresh food. The period from 1976 to 1979 was characterised by high coffee prices (Figure 4). From 1980 to 1983, coffee prices declined and, given continuing inflation, the prospect is for a continuing decline in prices relative to the cost of other goods and services. Low coffee prices are not unique to the period 1980-1983. They were also low in the years 1972 to 1975 (Figure 4). The difference between the earlier period and the more recent one is the prospect of employment.

By 1981 the PNG government was under severe financial pressure, because of low prices for major export commodities. The response was a reduction in public spending and loss of employment opportunity. In the local context, this meant that some men lost their jobs at the agricultural stations and everyone knew that prospects for finding work, especially for young men leaving school, were low. I suggest that low and falling coffee prices and reduced opportunity to obtain wage employment in 1981, 1982 and 1983 were directly responsible for the increase in lawlessness in 1982 and 1983 (the "rascal problem"). This perceived problem was a contributing factor in the people's decisions to move to the comparative security of individual forests/slope gardens.
Figure 4. Mean annual price of arabica coffee (Y grade green bean DIS, Lae) between 1965 and 1983 in constant 1980 prices.
INFLUENCE OF THE AGRICULTURAL STATION

Asiranka village is situated adjacent to the major agricultural research station in the highlands. It is reasonable to ask what effect the station has had on village agriculture. As Radford (1979, 1987) notes, the agricultural station from its beginning maintained a two-way relationship with its neighbours which was generally an amicable one. Asiranka people have provided labour for the station over a long period and hence gained early access to goods and cash. They assisted in building the Aiyura airstrip in 1937 and were first recruited to work as labourers on the station in March 1939 (R.F. Brechin, Aiyura Monthly Report, March 1939). Their involvement as labourers has continued until the present time. Labourers were initially paid with rations and a knife or an axe, but after February 1947, all payment was in cash (A.J. Schindler, Aiyura Annual Report 1946-47).

The villagers also had access to some assistance earlier than most other highlanders. For example, from 1938 to 1940, imported pigs were farmed out to local villagers by the Agricultural Station to upgrade the local pig strain (R.F. Brechin, Aiyura Monthly Report, June 1940). Schindler was involved in planting village coffee plots among Agarabi and Gadsup speakers in the Kainantu area as early as 1945 (Asaroka Patrol Post, Patrol Report 1944/45). In February 1949, station staff assisted the Aiyura villagers to establish a communal coffee block (G.K. Graham, Aiyura Monthly Report, February 1949). This block was later taken over by an individual from Asiranka who had been working on the agricultural station.

The Station purchased village grown coffee, at least until the mid-1950s (Aiyura Annual Report 1955-56). In 1951 the Aiyura villagers were given three head of cattle for various services rendered (presumably to the agricultural station) and they became the first owners of village cattle in the area (Young 1973, p 37).

Schindler believed that it would be advantageous to start an extension project in the Kainantu area. The aims would be: (1) encourage and develop the growing of vegetables, coffee and chinchona by villagers; (2) encourage re-forestation; (3) establishment of a small demonstration farm at Kainantu; and (4) any other measures which present themselves for encouraging mutual understanding of black and white people (A.J. Schindler, Aiyura Annual Report 1949-50). The older people at Asiranka recall that Schindler gave the people coffee and vegetable seeds, timber seedlings and a cross saw. Schindler distributed seed and seedlings to other highlanders who worked as Department of Agriculture trainees or employees (Donaldson and Good 1981).

Nevertheless casual observations in Asiranka do not suggest a strong influence from the station. The farming systems described here can be found elsewhere in the highlands, including recent changes such as the coffee/mixed vegetable gardens/casuarina integrated system. It is likely that innovations from the agricultural station, such as introduced sweet potato varieties and new food crops, were also widely distributed by labourers returning to their villages elsewhere in the highlands. Asiranka was one of many villages that received new technology
and ideas at about the same period. Some of this has been adopted into village agriculture, much has been rejected. The continuing close relationship between the Asiranka people and the agricultural station staff may have benefitted the latter, in the form of contact with village agriculture, more than the villagers.

CONCLUSION

There is sufficient land available under forest and scrub regrowth to allow low intensity gardening in these environments for some years before a return to more intensive systems in the grassland flats is necessary. The move back to the forest has been facilitated by the advent of steel tools because, before the people had steel tools, they were mostly restricted to areas of secondary regrowth.

The present study, although very incomplete, does indicate the need for a long term perspective. Even a 30 year study period in this village, for example from 1950 to 1980, would not have recorded the two major changes in land use and intensity of subsistence production that have occurred since the 1930s. B.J. Allen (personal communication) has for some years been advocating the need for long term monitoring of subsistence production systems in Papua New Guinea. Even the most complete long term study to date, that of Brookfield (1973) in Chimbu, is too short to allow definite conclusions to be made about parameters such as a change in the pig to people ratio. The present study supports Allen's call for long term monitoring projects.

ACKNOWLEDGEMENTS

Much of the data presented here were gathered whilst I was employed by the Papua New Guinea Department of Primary Industry, and based at Aiyura (1978 to 1983). I am grateful to the people of Asiranka Village for much information, especially Apolis Paibiko, Paibiko, Binifa, Aritme, Makao, Tupeno, Yabimare, Yasisime, Florat'nano, Shima, Yapato, Nointo, Laeke and Yuie. Others who assisted with information were Kiagi Nema (Aiyura), Aub Schindler (Brisbane), Bruce Hoy (Port Moresby), Bryant Allen (Canberra) and staff of the Division of Botany (Lae). Robin Hide commented on an earlier draft of the paper, but the inadequacies in interpretation that remain are mine.

POSTSCRIPT

From late August to early October 1984, I lived in Asiranka for five weeks to continue a long term study of variation in food supply. The move of agriculture out of the grassland flats continued during 1984 (Table 6).
REFERENCES


**NOTES**

For reviews and discussion on related topics, see: Radford (1987) for the most complete accounts of European exploration of the Kainantu area from 1919 until 1942; Radford (1979) (which is an extract from her thesis) on the development of the Highlands Agricultural Experiment Station at Aiyura; du Toit (1975) for an ethnography of a Gadsup village; Berndt (1952/3) on the reaction of nearby Kamano speaking people to European contact; Pataki-Schweizer (1980) for much information on the environment and ecology of the Gadsup, Tairora, Auyana and Awa speaking peoples; and Donaldson (1982) for a review of social relations and structure in the Eastern Highlands Province.
2Some older informants say that first contact was with Finschhafen evangelists who were not accompanied by a European. So first contact with Europeans may not have been in 1928, but at some other period in the mid to late 1920s.

3Schindler (1952) calculated the area of village lands as 1093 ha for a population of 370 persons. These figures include both present day Asiranka and Anamunapa villages. He states that the area under cultivation was 93 ha which gives a garden area of 2500 m² per person. This estimate is much higher than the recorded 834 m² per person in the present study (Table 5). A figure of 2500 m² per person is one of the highest for garden area per person in PNG. I am reluctant to conclude that crop area per person has declined by two-thirds over a 30 year period.

Pataki-Schweizer (1980, p 42) calculated the Asiranka village area as 620 ha for a population of 295 persons in 1963. His population figure is presumably derived from the Government census and would include absentees. The discrepancy between Pataki-Schweizer's figure of 620 ha and my figure of 445 ha is probably caused by the difficulty in separating village land on the forested ridges. The forest is used jointly by a number of villagers and there are no clear cut boundaries between the various villages in the forested area.

An annual population growth rate of 3.1 per cent for Asiranka is comparable with the figures of 3.2 per cent (crude growth rate) and 3.5 per cent (estimated annual population growth) for Gadsup speakers as a whole (Pakati-Schweizer 1980, p 116). Young (1973, p 49) gave the growth rate for Asiranka and Aiyura Villages as over 4 per cent per annum over the period 1952 to 1972. These villages had the highest population growth rate of all Gadsup and Agarabi villages because of inward migration due to local employment prospects.

4Asiranka people planted gardens in the forest in an altitudinal range of 1750 masl to 1830 masl in 1980-1982.

5The women are responsible for planting food gardens. They also weed and harvest the gardens and feed pigs. Men may assist with soil tillage and planting but their main input is clearing areas from forest and cane grass fallow, fence building, and digging and maintaining the major drains. Men plant the "male" crops of sugarcane and bananas.

6People today say that forest gardens are planted to four successive crops before fallowing. In the three and a half years that I measured garden areas planted, only one part of one garden was replanted after the first sweet potato crop, in the forest area. My experience elsewhere in PNG is that the stated number of crops planted on land before fallowing is a maximum rather than an average.

7The alleged sequence of events is as follows: "Chimbu" labourers caused trouble between the villagers and the officer in charge of the agricultural station (R.F. Brechin) when one labourer claimed to have been shot with an arrow by a villager. Police from Kainantu were called in. Police, under the control of Brechin, shot dead a man (Dawame) in the forest area and burnt the village houses. People ran away to Ontenu and to nearby hamlets. Later an army aircraft crashed on
landing at Aiyura (May 1942). The villagers were called to pull the aircraft off the airstrip. Three people did not assist (two men Akaiya and Kafoiya, and a woman, Mavene). They were shot dead by the police for not helping. The police were not under a European’s control at the time. No official records of these alleged killings have been found.

Later, it is claimed, police shot dead five Asiranka people near Ontenu (a man, Konano; a woman, Nontano; her daughter, Useko; a woman, Bebako; and a young girl, Nonendoru). Another woman shot in the leg recovered. The police were under the control of a patrol officer who was not with them when the shooting happened. This is likely to be the incident reported by P.O. (W.O.1) Haviland near Sonofi (which is near Ontenu) in November 1943 (ANGAU Monthly Report for Kainantu Sub-District, November 1943). These incidents are not isolated. Stories of beatings, gaolings, and summary executions by the Australian New Guinea Administrative Units, and the Papua New Guinean policemen serving with it, are widespread in PNG (Allen 1982).

Aub Schindler remembers this as the period when people moved down from the forest. Village informants suggest that it may have been about two years after the road to Kainantu was completed, that is, in 1946.

Gorecki (1979) postulated that the Wahgi swamp was abandoned prior to European penetration because of an epidemic, possibly of malaria. Malaria is not a consideration in changing land use in the Aiyura Basin. An early survey (1945) indicated that there was little or no malaria in the Kainantu/Aiyura area (Ewers and Jeffrey 1971, pp 96 & 101), although some transmission of malaria does now occur in the basin.

“Raskal” is a Melanesian Pidgin term (from the English rascal) that translates as ‘scoundrel’. It is applied to people who commit both petty and major crimes. The outsiders complaining of a breakdown in law and order were both Papua New Guineans and expatriates.
### APPENDIX


<table>
<thead>
<tr>
<th>Scientific name</th>
<th>Common name</th>
<th>Pre/post contact</th>
<th>Status</th>
<th>Part consumed</th>
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<tbody>
<tr>
<td><em>Abelmoschus manihot</em></td>
<td>Aibika</td>
<td>Pre 3</td>
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<td>Bulb</td>
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<td>Post 4</td>
<td>Bulb/stem</td>
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<td>Post 3</td>
<td>Bulb/stem</td>
<td></td>
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<td>Post 4</td>
<td>Leaf</td>
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</tr>
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<td></td>
</tr>
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<td>Fruit</td>
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<td>Flower head</td>
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<td>Fruit</td>
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<td>Post 4</td>
<td>Fruit</td>
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<td>Corm</td>
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<td>Cucumber</td>
<td>Pre 3</td>
<td>Fruit</td>
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<tr>
<td><em>Cucurbita moschata</em></td>
<td>Pumpkin</td>
<td>Post 3</td>
<td>Fruit/leaves</td>
<td></td>
</tr>
<tr>
<td><em>Cyanotis moluccana</em></td>
<td>-----</td>
<td>Pre 3/6</td>
<td>Leaves</td>
<td></td>
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<tr>
<td><em>Cyathea ?aenifolia</em></td>
<td>Tree fern</td>
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<td></td>
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<tr>
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<td>Post 4</td>
<td>Fruit</td>
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</tr>
<tr>
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<td>Carrot</td>
<td>Post 5</td>
<td>Root</td>
<td></td>
</tr>
<tr>
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<td>Wild desmodium</td>
<td>Pre 6</td>
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</tr>
<tr>
<td><em>Diciplerta papuana</em></td>
<td>-----</td>
<td>Pre 4</td>
<td>Leaves</td>
<td></td>
</tr>
<tr>
<td><em>Dioscorea alata</em></td>
<td>Greater yam</td>
<td>Pre 3</td>
<td>Tuber</td>
<td></td>
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<tr>
<td>Scientific name</td>
<td>Common name</td>
<td>Pre/post contact</td>
<td>Status</td>
<td>Part consumed</td>
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<td>---------------------</td>
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<tr>
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<td>Potato yam</td>
<td>Pre</td>
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<tr>
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<td>Kumu musong</td>
<td>Pre</td>
<td>4/6</td>
<td>Leaves/fruit</td>
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<td>Highland kapiak</td>
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<td>6/4</td>
<td>Leaves</td>
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<td>Finschia</td>
<td>Pre</td>
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<td>Lablab purpureus</td>
<td>Hyacinth bean</td>
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<td>4</td>
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<tr>
<td>Laçtuca sativa</td>
<td>Lettuce</td>
<td>Post</td>
<td>5</td>
<td>Leaves</td>
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<tr>
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<td>Bottle gourd</td>
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<tr>
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<td>Post</td>
<td>3</td>
<td>Fruit</td>
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<tr>
<td>Manihot esculenta</td>
<td>Cassava</td>
<td>Post</td>
<td>3</td>
<td>Root tuber</td>
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<td>Mulberry</td>
<td>Post</td>
<td>4</td>
<td>Fruit</td>
</tr>
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<td>Musa cv</td>
<td>Bananas</td>
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<td>2</td>
<td>Fruit</td>
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<tr>
<td>Nasturtium officinale</td>
<td>Watercress</td>
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<td>Oenanthe</td>
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<td>Marita</td>
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<td>Karuka</td>
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<td>passionfruit</td>
<td>Post</td>
<td>4</td>
<td>Fruit</td>
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<tr>
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<td>Yellow passionfruit</td>
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<td>4</td>
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<td>Parsley</td>
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<td>Lima bean</td>
<td>Post</td>
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<td>Phaseolus vulgaris</td>
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<tr>
<td>Physalis peruviana</td>
<td>Cape gooseberry</td>
<td>Post</td>
<td>6</td>
<td>Fruit</td>
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<td>Piper gibbilibum</td>
<td>Highland betel pepper</td>
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<td>Pea</td>
<td>Post</td>
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<td>Seed</td>
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<td>Psidium guajava</td>
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<td>Psophocarpus tetragonolobus</td>
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<td>Pre</td>
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<td>Tuber/leaves/beans</td>
</tr>
<tr>
<td>Raphanus sativus</td>
<td>Radish</td>
<td>Post</td>
<td>5</td>
<td>Root</td>
</tr>
<tr>
<td>Rheum rhaponticum</td>
<td>Rhubarb</td>
<td>Post</td>
<td>5</td>
<td>Stem</td>
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<tr>
<td>Rubus lasiocarpus</td>
<td>Black raspberry</td>
<td>Post</td>
<td>6</td>
<td>Fruit</td>
</tr>
<tr>
<td>Rubus moluccanus</td>
<td>Red raspberry</td>
<td>Pre</td>
<td>6</td>
<td>Fruit</td>
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### APPENDIX continued

<table>
<thead>
<tr>
<th>Scientific name</th>
<th>Common name</th>
<th>Pre/post contact(^2)</th>
<th>Status(^3)</th>
<th>Part consumed</th>
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</thead>
<tbody>
<tr>
<td>Rubus rosifolius</td>
<td>Red raspberry</td>
<td>Pre</td>
<td>6</td>
<td>Fruit</td>
</tr>
<tr>
<td>Rungia klossii</td>
<td>Rungia</td>
<td>Pre</td>
<td>2</td>
<td>Leaves</td>
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<tr>
<td>Saccharum edule</td>
<td>Lowland pitpit</td>
<td>Pre</td>
<td>3</td>
<td>Inflorescence</td>
</tr>
<tr>
<td>Saccharum officinarum</td>
<td>Sugarcane</td>
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<td>Stem</td>
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<td>Sechium edule</td>
<td>Choko</td>
<td>Post</td>
<td>3</td>
<td>Leaves/fruit</td>
</tr>
<tr>
<td>Setaria palmifolia</td>
<td>Highland pitpit</td>
<td>Pre</td>
<td>2</td>
<td>Stem</td>
</tr>
<tr>
<td>Solanum nodiflorum</td>
<td></td>
<td>Pre</td>
<td>6</td>
<td>Leaves</td>
</tr>
<tr>
<td>Solanum tuberosum</td>
<td>Potato</td>
<td>Post</td>
<td>3</td>
<td>Tuber</td>
</tr>
<tr>
<td>Trichosanthes pulleana</td>
<td></td>
<td>Pre</td>
<td>6</td>
<td>Fruit</td>
</tr>
<tr>
<td>Vicia faba</td>
<td>Broad bean</td>
<td>Post</td>
<td>4</td>
<td>Beans</td>
</tr>
<tr>
<td>Xanthosoma sagittifolium</td>
<td>Chinese taro</td>
<td>Post</td>
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<td>Cormels</td>
</tr>
<tr>
<td>Zea mays</td>
<td>Maize</td>
<td>Pre(^4)</td>
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<td>Cobs</td>
</tr>
<tr>
<td>Zingiber officinale</td>
<td>Ginger</td>
<td>Pre</td>
<td>3</td>
<td>Rhizome</td>
</tr>
</tbody>
</table>

Notes:

1. Does not include food species in the village area that are not consumed (*e.g.* lemon, mountain pawpaw, naranjilla), non-food cash or shade crops (*e.g.* crotalaria, casuarina). *Pueraria lobata* tubers are no longer grown at Asiranka, although some nearby villagers still grow a few. Only a very small proportion of the coffee crop is consumed in the village.

2. This indicates whether the species was acquired before or after direct contact with Europeans (about 1928).

3. 1. Major cultivated food or narcotic species
   2. Significant cultivated species
   3. Minor cultivated species
   4. Very minor cultivated species
   5. Very minor cultivated species, mainly grown for sale.

4. See further discussion in the text.
A REVIEW OF METHODS FOR MAINTAINING SOIL FERTILITY IN PAPUA NEW GUINEA FARMING SYSTEMS

A. S. Leng

Lowlands Agricultural Experiment Station, Keravat, East New Britain Province

ABSTRACT

The causes of soil fertility decline are discussed in relation to agricultural intensification. Soil fertility amelioration can be achieved by recycling crop residues and the use of legumes in crop rotations. The use of inorganic fertilisers is considered to be unacceptable for most of the food crop farming systems practised in Papua New Guinea at present, but its use will inevitably increase. The role of agroforestry in the development of continuous land use systems is considered. Rotations of cash crops and food crops are discussed, and it is concluded that the system has considerable potential, particularly for cocoa.

INTRODUCTION

In the last three decades there has been a general increase in the population, and people have begun to concentrate near urban centres. Even in remote areas, some people have left the villages which traditionally shifted with their gardening activities, and settled alongside new roads. At an increasing rate, people are also planting their land to perennial cash crops. All these factors have led to a shortage of land for the traditional system of farming which requires a long fallow period to allow soil fertility to regenerate.

In seasonally dry areas of the lowlands, vegetation fires burning through weeds established in old gardening areas have been a major factor preventing the re-establishment of the soil-regenerating tree fallow, and leading to the development of large areas of grassland. Repeated burning of these grasslands leads to loss of nutrients and a decline in fertility.

Attempts to combat declining yields due to declining soil fertility can be made in a number of ways. People can change to crops which will grow on soils of lower fertility, for example a change from taro to sweet potatoes has already occurred in many areas. Selection can also be made within a crop for varieties yielding well on soils of lower fertility. These varieties are often not available or so easily recognised in village circumstances and this is an area where researchers can help. Mixed cropping is another way of increasing the productivity of a piece of land by making better use of available nutrients, sunlight and labour. It is
already practised in Papua New Guinea (PNG). Attempts to improve the efficiency of the traditional, apparently random, mixture of crops meet with many problems.

Experiments to find the optimum spacing for maximum yield for more than two crops grown together are very complex, and the results depend on the growth habits of the varieties of each crop used. Extension of this type of precise information is often impossible due to personal preferences for varieties, and wide local environmental differences.

The techniques that have been considered so far for coping with declining soil fertility could be called the easy approaches. They attempt to maintain output per unit area of land and labour, and thus extract similar amounts of nutrients from a less fertile soil. The only way to make optimal use of limited production, and not remove more nutrients from the garden, is to use more efficient food preparation techniques, such as boiling in water rather than roasting and burning in ashes.

CONTINUOUS CROPPING AND DECLINE IN SOIL FERTILITY

Without an appropriate length of fallow, soil fertility will continue to decline. Ruthenberg (1980) considered that under intensive cultivation this decline could continue until yields are between nil and one third of the yield of newly cleared land. He does however suggest that on rich volcanic and alluvial soils the yields could remain higher.

Estimations of yield decline made from long running trials started in 1954 (Newton and Jamieson 1963; Bourke 1977) on the young volcanic soils at the Lowlands Agricultural Experiment Station (LAES) at Keravat suggest that this is correct. In a soil exhaustion trial with continuous cropping of sweet potato, by the sixth crop yields had dropped to about half the initial yield. The final yield was about 10 tonnes per hectare, with wide seasonal fluctuations of up to 50 per cent. Sweet potato cropping continued on the site and after twenty eight years of continuous cropping gave yields of about a quarter or a fifth of the original yields (using different varieties and narrower spacing). Only 30-40 per cent of this yield was of usable size roots and very few tubers were of marketable size. However this is an extreme case.

On an adjacent area of land where a three year rotation trial was planted, also in 1954, various crops besides sweet potatoes were grown. In some treatments, short-lived legumes were grown for a three month fallow, and longer-lived legume species were grown for an eighteen month fallow period in other treatments. With the long fallow treatment, yields of sweet potato declined after about eight years to approximately half the original yield, and then fluctuated around this level, not falling below 8 t/ha for the next 19 years.

Yields from the short fallow rotation fell to about a third of the initial yield, not falling below 5 t/ha over the same 19 year period. The yield comprised approximately 50 per cent each of marketable and unmarketable roots. In
rotations where peanuts (with their tops discarded for plant health reasons) were used instead of a three month legume fallow, the yields of sweet potatoes were slightly lower than with the three month fallow, but the yields of peanuts compensated for this loss. The yields of peanuts showed very wide seasonal fluctuations, with only a weak suggestion of a downward trend over the 19 years. The other crops in the rotation declined in yield at different rates. With other root crops, the size of the roots also declined as well as the yield. This rapidly reduced marketable yield, although it should be noted that what constitutes an acceptable size root depends on people’s circumstances.

From the results of other trials, yield decline is observed to occur relatively rapidly for sweet potato, and varies with variety. Immediately after a grass fallow, yields were found to include more than 70 per cent marketable roots (minimum 10 cm x 5 cm). This declined to 50-60 per cent in the second crop, and 30-40 per cent in the third consecutive crop. In the rotation trials, cropping cycles were planted in successive seasons to combat the wide seasonal fluctuations in yield which can occur. Even so, large seasonal variations in yield, of as much as 50 per cent, made precise figures difficult to obtain. Causes of these variations could include severe pest and disease attack, and differences between cultivars used. In East New Britain Province, as well as other parts of Papua New Guinea, many soils have a volcanic origin or have an addition of volcanic ash, which means that their basic level of fertility is high.

Some practices can be adopted which minimise the damaging effects of cropping on the soil. These aim to keep the soil covered at all times, thereby keeping the soil surface cool, and preventing erosion and leaching by reducing the amount of cultivation, and by the use of relay intercropping or living mulches.

In humid tropical climates, the cultivation of perennial crops is less damaging to the soil than arable cropping. This is because perennial crops do not require regular cultivations and thus exposure of the soil to erosive forces (Ruthenberg 1980). Bananas can be grown with relatively little soil disturbance and thus their wider cultivation is desirable in areas subject to soil erosion. Most of the other perennial food crops are trees which are as yet unselected and seasonal, and do not form a prominent part of the diet. Fortunately, at present the most widely cultivated cash crops are perennial. Other methods of maintaining soil fertility and yield output all require inputs of various kinds.

**RECYCLING OF CROP RESIDUES**

The traditional system of fertility maintenance involves a small labour input and the use of a large area of land and time to allow soil fertility to build up. As cropping systems change, these inputs have to be substituted for in some way, either as cash to buy fertiliser or, with varying degrees of success, by inputs of the grower’s own labour, utilising available organic materials. The amount of the input required will vary with the technique adopted. Particular techniques will work with less effort in some environments than in others. The aim of research should be to identify the most efficient system suitable for the local grower.
A simple labour intensive step that can be made towards maintaining soil fertility in an intensive system is the recycling of crop residues. The traditional approach to utilizing these residues in other parts of the world, where carry-over of weeds, pests and diseases is likely to be a problem, is to make them into compost.

In all the trials conducted at LAES where compost was included for comparison with the other organic manures available (other than animal waste) it has given the best results. However, composting involves a lot of labour, including carrying the material to and from the compost heap, turning it, protecting it from rain and the drying effects of sun and wind by making a house or pit, and the addition of water to maintain the correct moisture content. This latter practice also requires some degree of skill and dedication as does the timing of turning the heap (Leng 1982b). If these practices are not followed correctly then the pests and diseases are not killed, true compost is not formed, and much effort is wasted. Due to its high labour requirement and the skill and dedication needed, composting is unlikely to be a popular solution, though it may be used by schools in some circumstances.

Many of the materials that are available for making compost can, where they are suitable, be used as mulch or incorporated directly into the soil as green manures (Leng 1982a). Mulching involves less labour than composting and can further reduce labour requirements by suppressing weeds. However, due to decomposition by micro-organisms much of the nitrogen contained in mulches is lost to the atmosphere (Kang, Wilson and Sipkens 1981). Observations on the vigorous growth of plants where heaps of cocoa pods, weeds and lawn clippings are left beside crops highlights the benefits of very large quantities of mulches.

Where there are no serious pest and disease problems, direct incorporation of material into the soil will provide the maximum return of nutrients. The incorporation of plant residues is unpopular in manual agriculture because of the large labour input required. However, sweet potato cultivation offers a means of incorporating the material into the soil during the usual soil preparation process with little extra effort. It is easy to make a small hole on the site where the mound is to be made. The green manure is put into this hole and pressed down with the foot. The hole need not be very deep since part of the covering comes from the normal mounding operation. This planting method can be used where soil fertility is declining, for example at institutions and where village growers are short of land, have poor soil or very short fallow periods, and where they replant a sweet potato garden a second time.

Near Rabaul, on soils where the fertility is already declining due to excessive cropping, a garden is sometimes replanted to sweet potatoes until the yield becomes unacceptable (usually after two or three crops), then a switch is made to peanuts, continuing until the soil is exhausted. Finally, the soil is given a brief rest (C. Karman, personal communication). This system is often associated with growing crops for market.

Local extension officers in Rabaul became interested in the possibility of using green manure in an attempt to maintain yields. The obvious materials available
were weeds and old sweet potato vines. I therefore conducted experiments utilising these and other green manures (Leng 1982b).

On poor soil, following a poor crop of aibika, after incorporating 1.5 kilograms of sweet potato vines per mound (equivalent to the vine production of one mound), significant total sweet potato yield increases of 60 per cent were obtained over the control yield of 6.8 t/ha. The percentage of marketable roots was higher in the treated plots, and marketable yield was 95 per cent higher than the control. In two subsequent sweet potato crops, the yields and percentage marketable roots declined, but the treated plots maintained their advantage over the control plots, for both of the sweet potato varieties used. The incorporation of 1.5 kilograms of lawn grass cuttings maintained the yield and root size near that of the first harvest. No pest or disease problems were noted with any of these treatments. On a slightly more fertile site, following a grass fallow where initial control yields were 10 t/ha, no significant yield increases due to organic matter additions to the soil occurred in the first year.

In the second year, when yield of the control plots dropped to 6.7 t/ha and the percentage of total yield that was marketable was reduced from 66 per cent to 46 per cent, the incorporation of sweet potato vines was reasonably successful in maintaining these yield components near those of the first crop. In the third crop, total control yields were 7.15 t/ha. Total yield of mounds with sweet potato vines incorporated in them was 30 per cent higher, and due to an increase in tuber size the marketable yield of the treated plots was almost twice that of the control.

Another trial was planted at a similar time on land (after a grass fallow) where the initial control yields were 18.9 t/ha. Here there were no significant yield benefits from the incorporation of sweet potato vines at a rate of one kilogram per mound alone or combined with 250 grams of Gliricidia sepium leaves, or artificial fertiliser at the rate of 150 kg/ha nitrogen and 120 kg/ha potassium. The growth period for this trial was during a particularly dry season, and it showed that incorporating this material into the mounds did not have any adverse effects under these conditions.

For the second crop, total yield of the control plots had declined to 10.7 t/ha (which may partly have been a seasonal effect) and there was again no significant difference in total yield between the control and the treatments. However, the proportion of total yield that was marketable for the control had declined from 46 per cent to 44 per cent whereas the other treatments had better maintained their root size and therefore had significantly higher marketable yields: 30 per cent more for sweet potato vines alone; 50 per cent more for vines plus Gliricidia leaves; and 44 per cent more for the artificial fertiliser. No problems with pests or diseases were noticed with any treatments.

Field trials and demonstrations of the use of sweet potato vines by extension staff have produced yield benefits acceptable to growers, but adoption of the technique has been poor. For this technique to be effective, soil fertility has to fall considerably below that of a bush fallow, or be inherently very low. Inability to identify sites at the right level of infertility could lead to disappointments in extension.
The recycling of crop residues from an area of land will not provide sufficient nutrients to maintain the yield of crops grown on that area, though it does help to reduce the rate of decline. The addition of nutrients from outside sources is required. From recycling garden wastes it is a short step to introducing other waste products to the garden, such as lawn cuttings, slashed grass, leaves and various cash crop wastes such as cocoa pods and coffee pulp (Siki 1980; Bourke 1982; Leng 1982a).

At Keravat we have conducted a number of trials comparing various rates of cocoa pod application with compost and artificial fertilisers, on soils of different levels of fertility. A preliminary trial was conducted on very exhausted soil which had been cropped for the previous 28 years with sweet potatoes. No significant yield improvements occurred after the first application. After the second application, compost at the rate of 18.5 t/ha and cocoa pods at the rate of 32 t/ha gave a significant increase in yield of nearly 100 per cent over the control. However, the best plot yield for the compost treatment was still only 9.9 t/ha. This may have been due partly to the plant spacing used. A lower level of cocoa pods (12.3 t/ha) produced no significant change in yield. Increases in yield of a subsequent peanut crop were achieved with the addition of compost, and both levels of cocoa pods.

With the next crop of sweet potatoes, the total yields had risen due to seasonal variations, the presence of a preceding break crop, and closer spacing. The highest total yield was 18.4 t/ha using 18.5 tonnes of cocoa pods and 100 kilograms of nitrogen per hectare, followed by 16.7 t/ha with artificial fertiliser. The second highest yield was 14.9 t/ha, using 32 t/ha of cocoa pods. This represents an increase of more than 100 per cent over control yields. The average size of the harvested roots had also increased by 100 per cent over the previous crop. Thus marketable yield was 200 per cent higher than the control, although the majority of these tubers were on the border line for size, and were thus "acceptable" rather than "marketable". This still only represented a yield of "marketable" roots of 8.0 t/ha, 6.8 t/ha and 6.3 t/ha respectively from the three treatments. In this trial, the cocoa pods used were about two months old and had been taken from the heap outside the fermentary where they had been exposed to the rain.

On a slightly more fertile soil, yield increases due to the application of cocoa pods at 32 t/ha, and compost at 32 t/ha, over the control yield of 10 t/ha, were not significant in the first year but they significantly reduced the rate of decline in total yield in the second year. They also maintained the proportion of marketable roots (which was 76 per cent more than the control) giving nearly double the marketable yield compared to the control plots. In the third crop there was again no significant increase in total yield, but root size was once more improved by the treatments and their marketable yield was again almost double that of the control. Yields of all treatments, including the control, had increased slightly over the second crop due to seasonal variations. The addition of cocoa pods and other materials are unlikely to restore the yield and root size to that obtained from fallowed ground, but they will improve on the basic yield produced, depending on the amounts used.

As large quantities of cocoa pods are required, considerable labour is involved in carrying them to the garden. The best way to utilise these bulky materials is to
Benjamin and Wapi (1982) found that settlers in the West New Britain Oil Palm Scheme (where soils are similar to those on the Gazelle Peninsula) had cleared garden areas varying from 0.035 ha to 0.063 ha per person. The larger areas were developed by people producing crops for market. The total garden area per family varied from 0.3 ha to 0.4 ha. On this basis, it can be inferred that the area planted to cocoa in NSP would be equivalent to that required for 3.5-5 years fallow. If the total area available is equivalent to 10 years fallow, it would be worth investigating the system since the highly productive life of cocoa under present village management conditions is relatively short due to uncontrolled pests and diseases.

Many areas of ENBP may already be beyond help from this system since the main cause of the land shortage problem is probably high population. In this province the situation is complicated by the traditionally accepted practice of growing food crops on other people's land (with their consent). Some people travel a considerable distance, sometimes by vehicle, to work on their own or other people's land for the day, or for a week or more. One problem associated with this system of borrowing land is that the growers may not have much interest in maintaining the long term fertility of the soil.

**OIL PALM/FOOD CROP SYSTEMS**

A system of rotational redevelopment is already being practised on the oil palm settlement schemes in West New Britain, but the situation there is different and not so favourable as for cocoa redevelopment. The settler blocks are each about six hectares in area. Originally the front two-thirds was planted to oil palm and the rear third was used for food cropping. When the front palms needed replanting, the rear third was planted and the front third was cleared and replanted. The middle third was then cleared and left for food cropping until the other sections needed replanting. Future replanting follows a similar pattern, with the new palms being brought to a bearing stage as intercrops in the food garden area before the next area of palms is removed.

Food crops planted immediately after oil palm has been cleared have given poor yields (Benjamin and Wapi 1981). Observations of these crops indicated that they lacked vigour and had symptoms of leaf yellowing. For ease of management of the oil palms, the lower fronds are removed to allow access to the bunches. These fronds are stacked in rows between the palms. Alternate rows between the palms are left clear and used as pathways. The fronds are green when they are cut, and rot down fairly quickly to produce a ridge of black compost about thirty to sixty centimetres high and 1.5 metres wide, covered with undecomposed and partly rotted fronds. Crops grew on this material fairly well, although taro was not very vigorous. The path rows and other areas between the trees where fronds were not heaped were bare earth, with little humus and obvious grains of sand and pebbles showing on the surface as a result of erosion. Crops did not grow well on these areas, nor did weeds.

In an experiment which had to be terminated early because of fire damage, the fertiliser value of bunch ash (a waste product of the oil extraction process) was
assessed. The yields from the path rows in this trial were half those from the frond rows. There appeared to be no beneficial effect from bunch ash application to either frond rows or path rows. This suggested that nitrogen was limiting growth as it only occurs in insignificant amounts in the ash, which is composed mainly of phosphorus, potassium, calcium, magnesium and other minor nutrients. On the frond rows some of these elements would have been provided when the undecomposed fronds were burnt off during the clearing process, so the application of bunch ash does not appear to be a priority. Where good stands of Pueraria existed before the oil palm canopy closed, seeds germinated after clearance of the old palms, but Pueraria takes some time to re-establish soil fertility.

It appears therefore that there is a problem for subsistence gardens with the oil palm scheme. For reasons of ease of layout of the oil palm blocks, areas alongside creeks and sloping land are not used for oil palm and can thus be used for gardening. As these areas are small, they will probably be intensively cultivated. Agroforestry is an appropriate system for these areas. It would help to control erosion, and would provide firewood which is in short supply. There is also some possibility of permanently intercropping Pueraria and certain oil palm genotypes which in trials at wider spacings than the present practice gave the same yields per hectare. This system has long term benefits for both oil palm and food crops, and may allow the intercropping of food crops amongst established palms. The situation of the village growers near the scheme may be more problematic. If they plant too much of their land to oil palm, leaving insufficient for food gardening and fallowing, and the oil palm severely depletes soil fertility, they may not be able to grow enough food for their needs.

CONCLUSION

The maintenance of soil fertility requires some form of inputs. The long term fallow appears to be the best way of maintaining fertility but it is impractical in densely populated areas, and the use of purchased fertilisers is not yet acceptable. Some efforts can be made to reduce the rate of decline in soil fertility during cropping by the adoption of certain crops and cropping systems. Any form of cropping that leads to constant cultivation and exposure of the soil will speed the deterioration of the soil and should be kept to a minimum. The cultivation of bananas and perennial crops should be encouraged, preferably in combination with some leguminous species as a living mulch. This, combined with mixed relay cropping of short term arable crops grown in an agroforestry system, would appear to be the best low input approach to a semi-intensive system aimed at reducing the decline in soil fertility or increasing the basic stable yield level. Additional processes for maintaining soil fertility with organic material can be adopted where appropriate and necessary.

Some practices for increasing the efficiency of the fallow by sowing leguminous cash crops can be adopted without too much effort, and can be incorporated with an agroforestry system. Cash crops should preferably be perennial species such as those already adopted, and careful consideration of the long term effect on soils should be given to any plans to encourage arable cropping on a large scale. Some perennial cash crops such as cocoa seem to be less damaging to the soil, from the
point of view of food crops, than others such as oil palm. However, some diversification in cash crops is desirable for economic stability. Thus careful consideration should be given to designing cash cropping schemes which minimise fertility decline.

In the long term, with increasing demands on the soil being made by an increasing population, fertilisers will have to be used to replace the land area once used for fallowing, otherwise output and living standards will decline. The introduction of profitable cash crops will enable people to purchase fertilisers when they are required.

The farmers themselves need to decide the level to which soil fertility will have to fall before they take action. Firewood shortages and the planting of large areas to cash crops may encourage people to adopt remedies before all the land is seriously affected.

REFERENCES

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FARMING PATTERNS IN FOOD GARDENS: AN ANALYTICAL APPROACH

Chimnoy Koley and Zenuddin Waliji

Rural Statistics Section, Policy Planning and Coordination Branch, Department of Primary Industry, Konedobu, National Capital District

ABSTRACT

The results of the series of smallholding crop surveys carried out in nine provinces so far indicate that there is a diversity in cropping patterns in food gardens among the provinces. However, when these provinces are grouped as three zones, namely, highlands, coastal (mainland) and island zones, it becomes apparent that the farming practices in the highlands zone differ significantly from those in the coastal and the islands zones, whereas the difference between coastal and island zones is not statistically significant. There are also indications that there may have been some shift in cultivation practices in food gardens, especially in the lowlands. Crops such as bananas and sugarcane have replaced taro and yam in these areas during the last ten years, although sweet potato retains its traditional stronghold in the highlands area. The analysis further indicates that farmers' involvement in cash gardens is at the expense of food gardening and, despite enormous potential fisheries resources, fishing is still a relatively minor occupation.

INTRODUCTION

The Rural Statistics Section of the Policy, Planning and Coordination Branch of the Department of Primary Industry (DPI) has been involved in a series of smallholding crop surveys in a number of provinces since 1979. These have been carried out in order to provide information on cultivation practices in these provinces. The aim is to cover all 19 provinces so as to provide a comprehensive cultivation pattern for the country as a whole. However, several constraints, mainly administrative and financial, have stood in the way of completing this work. To date surveys have been completed in nine provinces, namely East Sepik, New Ireland, Eastern Highlands, Enga, Milne Bay, Madang, East New Britain, Morobe and Central. Field work in the tenth, North Solomons, is in progress. In each province, the survey took the form of a stratified two-stage sample, where administrative districts provided the geographical stratification. Households within villages were then selected in two stages by random sampling methods. The emphasis was on quantitative information on cash crops such as coffee, cocoa and copra. However, information was also collected on types of crops grown in
food gardens and this forms the basis of the present paper. Even though there are limitations in coverage of the country as a whole, the surveys do, nevertheless, indicate the nature of farming patterns in food gardens in the country.

RANKING OF FOOD CROPS

The survey results (DPI Rural Statistics Bulletins 1981, 1982; unpublished results) illustrate the diversity of food crop cultivation practices between the provinces, as well as between districts within a province. On the basis of the proportion of gardens in which a crop is grown, a ranking order of the relative importance of the main food crops has been established for the nine provinces surveyed so far (Table 1). It is interesting to note that cooking banana (diploid) is the most frequent crop in coastal provinces, namely, Central, Madang, Milne Bay, Morobe and New Ireland, whereas sweet potato is the predominant crop in two highlands provinces, namely, Eastern Highlands and Enga. The most frequent crop in East New Britain, according to the survey results, is eating ('mau') banana (triploid), whereas aibika is the most common crop in East Sepik Province. The results also reveal that more varieties of crops are grown in food gardens of coastal provinces than of highlands provinces (c.f. Bourke, 1982).

CROP ZONES AND STATISTICAL VARIATIONS

In order to test whether there are statistically significant variations between the ranking orders of crops, 15 main crops were again ranked (Table 2). For the purpose of the statistical tests, the provinces have been grouped into three crop zones, namely, the highlands zone comprising Eastern Highlands and Enga provinces, the coastal (mainland) zone comprising Central, Milne Bay, Morobe, Madang, and East Sepik, and the islands zone comprising East New Britain and New Ireland provinces.

A number of statistical tests have been carried out. The first set of tests were designed to see whether the ranks agree between provinces within a zone, for all three crop zones. The rank correlation coefficient (Goon, Gupta and Dasgupta 1976) between the provinces in each of the highlands and islands zones ($r = 0.792$ and $0.688$ respectively) was found to be as highly significant as was the coefficient of concordance (Moroney 1970) interchange between the provinces in the coastal zone ($W = 0.646$). (In the case of the latter it was not possible to obtain a correlation coefficient as there were more than two provinces.) The inference, therefore, was that the ranking orders agree between provinces within each zone. Thus it appears that cropping patterns within a zone are, by and large, similar, and it was thus possible to pool the ranks for all three zones (Table 3).

The next set of tests was carried out between all three possible pairs of zones, namely between coastal and island zones, coastal and highlands zones, and islands and highlands zones. The interesting result was that whereas the rank correlation coefficient between coastal and island zones was highly significant ($r = 0.918$), the other two tests, i.e. highlands with coastal ($r = 0.276$) and highlands with islands ($r = 0.176$), failed to show significant correlation.
Table 1. Ranks\(^1\) of main food crops in nine provinces surveyed, in order of relative importance.\(^2\)

<table>
<thead>
<tr>
<th>Rank</th>
<th>New Ireland</th>
<th>East New Britain</th>
<th>Eastern Highlands</th>
<th>Enga</th>
<th>East Sepik</th>
<th>Madang</th>
<th>Morobe</th>
<th>Milne Bay</th>
<th>Central</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cooking banana</td>
<td>Ripe banana</td>
<td>Sweet potato</td>
<td>Sweet potato</td>
<td>Aibika</td>
<td>Cooking banana</td>
<td>Cooking banana</td>
<td>Cooking banana</td>
<td>Cooking banana</td>
</tr>
<tr>
<td>2</td>
<td>Colocasia taro</td>
<td>Sugarcane</td>
<td>Sugarcane =</td>
<td>Cooking banana</td>
<td>Colocasia taro</td>
<td>Sugarcane</td>
<td>Cassava</td>
<td>Ripe banana</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Ripe banana</td>
<td>Aibika =</td>
<td>Pitpit =</td>
<td>Ripe banana =</td>
<td>Sugarcane</td>
<td>Aibika</td>
<td>Ripe banana =</td>
<td>Sugarcane</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Sweet potato =</td>
<td>Cassava =</td>
<td>Ripe banana =</td>
<td>Yam =</td>
<td>Pitpit</td>
<td>Pitpit</td>
<td>Aibika =</td>
<td>Sweet potato</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Aibika =</td>
<td>Cooking banana</td>
<td>Cooking banana</td>
<td>Pawpaw =</td>
<td>Pitpit</td>
<td>Pitpit</td>
<td>Pitpit</td>
<td>Aibika =</td>
<td>Sweet potato</td>
</tr>
<tr>
<td>6</td>
<td>Pawpaw</td>
<td>Colocasia taro</td>
<td>Ripe banana =</td>
<td>Colocasia taro</td>
<td>Kongkong taro =</td>
<td>Colocasia taro</td>
<td>Sweet potato</td>
<td>Cassava =</td>
<td>Pumpkin =</td>
</tr>
<tr>
<td>7</td>
<td>Sugarcane =</td>
<td>Kongkong taro</td>
<td>Ripe banana =</td>
<td>Pawpaw =</td>
<td>Ripe banana</td>
<td>Pawpaw</td>
<td>Pumpkin =</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Cassava =</td>
<td>Sweet potato</td>
<td>Sugarcane</td>
<td>Cassava</td>
<td>Kongkong taro =</td>
<td>Yam</td>
<td>Colocasia taro</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Yam</td>
<td>Pitpit</td>
<td>Pitpit</td>
<td>Sweet potato</td>
<td>Pawpaw =</td>
<td>Pumpkin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Kongkong taro</td>
<td></td>
<td></td>
<td></td>
<td>Ripe banana</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^1\)Based on percentage of households growing food crops.

\(^2\)Crops which are grown in 50 per cent or more gardens (except Milne Bay).

Source: Provincial Smallholding Crop Surveys (1979-1983), Rural Statistics Section, Department of Primary Industry.
Table 2. Ranking order of 15 main food crops for nine Provinces.1

<table>
<thead>
<tr>
<th>Food crop</th>
<th>New Ireland</th>
<th>East New Britain</th>
<th>Eastern Highlands</th>
<th>Enga</th>
<th>East Sepik</th>
<th>Madang</th>
<th>Morobe</th>
<th>Milne Bay</th>
<th>Central</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooking banana</td>
<td>1</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Sugarcane</td>
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<td>2</td>
<td>2.5</td>
<td>2</td>
<td>8</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Ripe banana</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>9</td>
<td>4</td>
<td>10</td>
<td>7</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Colocasia taro</td>
<td>2</td>
<td>6.5</td>
<td>8</td>
<td>3</td>
<td>6</td>
<td>2</td>
<td>6</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Sweet potato</td>
<td>4.5</td>
<td>8</td>
<td>1</td>
<td>1</td>
<td>10</td>
<td>9</td>
<td>4</td>
<td>6.5</td>
<td>5</td>
</tr>
<tr>
<td>Aibika</td>
<td>4.5</td>
<td>3.5</td>
<td>14</td>
<td>12.5</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Pitpit</td>
<td>13</td>
<td>9</td>
<td>2.5</td>
<td>4</td>
<td>9</td>
<td>5</td>
<td>5</td>
<td>11</td>
<td>13</td>
</tr>
<tr>
<td>Pawpaw</td>
<td>6</td>
<td>10</td>
<td>(15)</td>
<td>14</td>
<td>4</td>
<td>7</td>
<td>8.5</td>
<td>6.5</td>
<td>10</td>
</tr>
<tr>
<td>Cassava</td>
<td>7.5</td>
<td>3.5</td>
<td>9</td>
<td>12.5</td>
<td>15</td>
<td>8</td>
<td>11</td>
<td>2</td>
<td>6.5</td>
</tr>
<tr>
<td>Kongkong taro</td>
<td>10</td>
<td>6.5</td>
<td>10</td>
<td>11</td>
<td>7</td>
<td>6</td>
<td>8.5</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Yam</td>
<td>9</td>
<td>11</td>
<td>11</td>
<td>(15)</td>
<td>4</td>
<td>11</td>
<td>12</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Pumpkin</td>
<td>(15)</td>
<td>12</td>
<td>7</td>
<td>6</td>
<td>14</td>
<td>13</td>
<td>10</td>
<td>10</td>
<td>6.5</td>
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<tr>
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<td>12</td>
<td>12</td>
<td>14</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>Ginger</td>
<td>11</td>
<td>15</td>
<td>12</td>
<td>10</td>
<td>13</td>
<td>14</td>
<td>13</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>Onion</td>
<td>14</td>
<td>14</td>
<td>13</td>
<td>8</td>
<td>11</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
</tbody>
</table>

1When two or more crops have the same rank, the average rank is given.
2Rank (15) has been allocated to the least important crop belonging to the list.
Source: Provincial Smallholding Crop Surveys (1979-1983), Rural Statistics Section, Department of Primary Industry.
The conclusion can thus be drawn that farming practices in the highlands zone differ significantly from those in coastal (mainland) as well as islands zones, whereas the difference between coastal and islands zones is not statistically significant.

SHIFT IN CULTIVATION PRACTICES

In the absence of more detailed quantitative information on crops in food gardens, and due to a lack of uniformity in data collection, it was difficult to establish and measure changes in cultivation patterns. Nevertheless, there are indications that there may have been some shift in cultivation practices in food gardens during the last ten to twelve years, especially in the lowlands.

On the basis of maps of principal food crops and their combinations (Ward and Lea 1970), an empirical ranking order of the main crops as in 1970 was established for the same nine provinces (Table 4). The limitations in making the comparison are that fewer crops were recorded by Ward and Lea (1970), the emphasis being only on the main ones, and also that no distinction was drawn between two types of taro ('tru' (Colocasia esculenta) and 'kongkong' (Xanthosoma sagittifolium)) and two types of bananas, as in Table 1.

Table 3. Pooled ranks of 15 main food crops in three crop zones.

<table>
<thead>
<tr>
<th>Food crop</th>
<th>Islands zone</th>
<th>Coastal zone</th>
<th>Highlands &amp; Mainland zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooking banana</td>
<td>2</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Sugarcane</td>
<td>5</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Ripe banana</td>
<td>1</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Colocasia taro</td>
<td>4</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Sweet potato</td>
<td>7</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Aibika</td>
<td>3</td>
<td>3</td>
<td>14</td>
</tr>
<tr>
<td>Pitpit</td>
<td>11</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Pawpaw</td>
<td>8</td>
<td>7</td>
<td>15</td>
</tr>
<tr>
<td>Cassava</td>
<td>6</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>Kongkong taro</td>
<td>9</td>
<td>11</td>
<td>9.5</td>
</tr>
<tr>
<td>Yam</td>
<td>10</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>Pumpkin</td>
<td>14</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>Corn</td>
<td>12</td>
<td>13</td>
<td>7</td>
</tr>
<tr>
<td>Ginger</td>
<td>13</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>Onion</td>
<td>15</td>
<td>15</td>
<td>9.5</td>
</tr>
</tbody>
</table>

1New Ireland and East New Britain. 2East Sepik, Madang, Morobe, Milne Bay and Central. 3Eastern Highlands.
Table 4. Ranks of main food crops\(^1\) (as in 1970) for nine provinces.

<table>
<thead>
<tr>
<th>Rank</th>
<th>New Ireland</th>
<th>East New Britain</th>
<th>Eastern Highlands</th>
<th>Enga</th>
<th>East Sepik</th>
<th>Madang</th>
<th>Morobe</th>
<th>Milne Bay</th>
<th>Central</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sweet potato</td>
<td>Colocasia taro</td>
<td>Sweet potato</td>
<td>Sweet potato</td>
<td>Colocasia taro</td>
<td>Colocasia taro</td>
<td>Colocasia taro</td>
<td>Colocasia taro</td>
<td>Cooking banana</td>
</tr>
<tr>
<td>2</td>
<td>Colocasia taro</td>
<td>Kongkong taro</td>
<td>Kongkong taro</td>
<td>Kongkong taro</td>
<td>Kongkong taro</td>
<td>Kongkong taro</td>
<td>Kongkong taro</td>
<td>Kongkong taro</td>
<td>Ripe banana</td>
</tr>
<tr>
<td>3</td>
<td>Kongkong taro</td>
<td>Cooking banana</td>
<td>Yam</td>
<td>Yam</td>
<td>Yam</td>
<td>Yam</td>
<td>Sweet potato</td>
<td>Yam</td>
<td>Yam</td>
</tr>
<tr>
<td>4</td>
<td>Yam</td>
<td>Ripe banana</td>
<td>Cooking banana</td>
<td>Sweet potato</td>
<td>Sweet potato</td>
<td>Yam</td>
<td>Sweet potato</td>
<td>Sweet potato</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Cooking banana</td>
<td>Ripe banana</td>
<td>Ripe banana</td>
<td>Cooking banana</td>
<td>Cooking banana</td>
<td>Cooking banana</td>
<td>Cooking banana</td>
<td>Cooking banana</td>
<td>Colocasia taro</td>
</tr>
<tr>
<td>6</td>
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<td>Ripe banana</td>
<td>Ripe banana</td>
<td>Ripe banana</td>
<td>Ripe banana</td>
<td>Ripe banana</td>
<td>Kongkong taro</td>
</tr>
</tbody>
</table>

\(^1\)No distinction has been made between types of taro and banana.

**Source:** Ward and Lea (1970; Maps 30 & 31).
Some interesting observations can however be made when Table 3 is compared with Table 4. In Milne Bay, Morobe, Madang and East New Britain provinces, banana ('cooking' in most cases) has replaced taro as the most frequent crop (Rangai 1982). Sweet potato retains its traditional stronghold in the highlands provinces (i.e., Eastern Highlands and Enga) though it is replaced by cooking banana in New Ireland province. In the coastal (mainland as well as islands) provinces, sugar cane is apparently now far more frequent than yams. However, in the absence of any statistical tests, these observations on shifting cultivation must be regarded as empirical and treated with caution (see also Bourke 1982).

Table 5. Rural population (10 years and above) engaged in agricultural occupation (provisional).

<table>
<thead>
<tr>
<th>Province</th>
<th>Total</th>
<th>Engaged in farming or fishing for food and sale</th>
<th>Engaged in farming or fishing for subsistence only</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Number</td>
<td>Per cent</td>
</tr>
<tr>
<td>Central</td>
<td>69,675</td>
<td>12,589</td>
<td>18.1</td>
</tr>
<tr>
<td>Chimbu</td>
<td>128,212</td>
<td>50,595</td>
<td>39.5</td>
</tr>
<tr>
<td>E. New Britain</td>
<td>64,408</td>
<td>19,731</td>
<td>30.6</td>
</tr>
<tr>
<td>East Sepik</td>
<td>133,220</td>
<td>55,781</td>
<td>41.9</td>
</tr>
<tr>
<td>East. Highlands</td>
<td>171,953</td>
<td>65,341</td>
<td>38.0</td>
</tr>
<tr>
<td>Enga</td>
<td>114,645</td>
<td>19,589</td>
<td>17.1</td>
</tr>
<tr>
<td>Gulf</td>
<td>38,286</td>
<td>5,412</td>
<td>14.1</td>
</tr>
<tr>
<td>Madang</td>
<td>117,808</td>
<td>18,681</td>
<td>15.9</td>
</tr>
<tr>
<td>Manus</td>
<td>13,646</td>
<td>1,857</td>
<td>13.6</td>
</tr>
<tr>
<td>Milne Bay</td>
<td>29,461</td>
<td>14,286</td>
<td>18.0</td>
</tr>
<tr>
<td>Morobe</td>
<td>154,755</td>
<td>59,711</td>
<td>38.6</td>
</tr>
<tr>
<td>New Ireland</td>
<td>36,851</td>
<td>5,637</td>
<td>15.3</td>
</tr>
<tr>
<td>N. Solomons</td>
<td>64,889</td>
<td>21,626</td>
<td>33.3</td>
</tr>
<tr>
<td>Northern</td>
<td>39,238</td>
<td>11,003</td>
<td>28.0</td>
</tr>
<tr>
<td>S. Highlands</td>
<td>153,936</td>
<td>24,369</td>
<td>15.8</td>
</tr>
<tr>
<td>W. New Britain</td>
<td>39,495</td>
<td>10,380</td>
<td>26.3</td>
</tr>
<tr>
<td>West Sepik</td>
<td>73,735</td>
<td>9,998</td>
<td>13.6</td>
</tr>
<tr>
<td>Western</td>
<td>45,295</td>
<td>8,768</td>
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</tr>
<tr>
<td>W. Highlands</td>
<td>156,316</td>
<td>44,448</td>
<td>28.4</td>
</tr>
</tbody>
</table>

1Adjusted.
CASH VERSUS SUBSISTENCE AGRICULTURE

Table 5 shows the number and percentage of the rural population aged ten years and above who participate in cash earning as well as subsistence agriculture, for all 19 provinces, on the basis of the 1980 National Population Census (National Statistical Office 1982).

The total of these two groups (i.e. the economically active population in agriculture) varies between 40 per cent (Milne bay and New Ireland) and 65 per cent (Chimbu), and it is apparent that the activities in cash agriculture adversely affect those of subsistence farming. The negative correlation between the two variables ($r = -0.728$) is found to be highly significant. Thus it appears that farmers' involvement in cash gardens is, by and large, at the expense of food gardening, though there may still be many other socio-economic factors affecting these activities (Lawrence 1982).

FISHING AS A SOURCE OF LIVELIHOOD

It is often said that Papua New Guinea, with its long coastline and its large economic fishing zone, has tremendous potential fisheries resources. However, the analysis of results of six coastal provinces surveyed so far (Table 6) indicates that though a substantial number of households are engaged in fishing activities, only a handful consider it to be a major activity. In Central province about 20 per cent of households have fishing as their major occupation, in New Ireland the proportion is 10 per cent, and in Morobe it is about 8 per cent. Less than 5 per cent of households in East New Britain, Madang and Milne Bay consider fishing to be a major source of livelihood.

CONCLUSION

The foregoing observations and analysis are an attempt by the authors to highlight some indicators of sources of food and their inter-relationships. As has been mentioned earlier, limitations relating to data collection methods, and a lack of uniformity have restricted the scope of the conclusions (cf. Eele 1983). It is, however, hoped that the present exercise may help planners to realise the need for more extensive analysis in the field of food and nutrition statistics.

REFERENCES


<table>
<thead>
<tr>
<th>Province</th>
<th>Total households</th>
<th>Households with fishing activity</th>
<th>Households with fishing as:</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Major activity</td>
</tr>
<tr>
<td>Central</td>
<td>21,107</td>
<td>9,328</td>
<td>4,152</td>
</tr>
<tr>
<td>E. New Britain</td>
<td>14,383</td>
<td>6,791</td>
<td>527</td>
</tr>
<tr>
<td>Madang</td>
<td>47,345</td>
<td>10,564</td>
<td>1,229</td>
</tr>
<tr>
<td>Milne Bay</td>
<td>21,044</td>
<td>16,588</td>
<td>101</td>
</tr>
<tr>
<td>Morobe</td>
<td>44,979</td>
<td>14,985</td>
<td>3,431</td>
</tr>
<tr>
<td>New Ireland</td>
<td>12,025</td>
<td>9,339</td>
<td>1,210</td>
</tr>
</tbody>
</table>

1Information on fishing activities were not collected in East Sepik, Eastern Highlands and Enga Provinces.


PART III:
AGRONOMY
AGRONOMIC RESEARCH IN PAPUA NEW GUINEA: PAST EFFORTS AND FUTURE PROSPECTS

V. Kesavan

Department of Agriculture, University of Papua New Guinea, Port Moresby

ABSTRACT

This paper reviews the agronomic research carried out in Papua New Guinea since 1930. A total of 1230 trials on 77 crop species have been carried out within the country, most of which have been undertaken by the staff of the Department of Primary Industry. The emphasis in the past was on individual crops and variety trials. Rice and introduced vegetables received the greatest attention up to 1970. Since then, the emphasis has shifted towards traditional crops such as sweet potato, and components of farming systems considered to be desirable or suitable for the village farmer. Some of the constraints to research are considered, together with the impact of research on farming practices. Possibilities for integrated or multi-disciplinary research with on-farm adaptive trials are discussed.

INTRODUCTION

The history of agronomic research in Papua New Guinea (PNG) can be traced back to 1928 when the first Agricultural Experiment Station was established at Keravat, East New Britain Province. Up until 1950, research efforts were concentrated on tree crops grown for export. The next decisive step came in that year when the New Guinea nutrition survey expedition identified nutritional problems in some areas of the country (Hipsley and Clements 1950). This prompted the Department of Agriculture, Stock and Fisheries to initiate work on rice and peanuts. With the survey of indigenous agriculture carried out in 1963, the important role played by the subsistence producer in feeding the nation became apparent (Walters 1963; Macewan 1978). The emphasis of agronomic research, however, was still on crops such as rice and introduced vegetables. The traditional food crops and cropping systems used in Papua New Guinea received scant attention until 1970.

Since independence, more emphasis has been placed on improving food crop production, though the effort has been placed largely on individual crops. The concept of farming systems research and its application was also accepted in the late nineteen seventies. Recognition for food crop research gained momentum with the creation of the Horticulture Section within the Department of Primary
Industry (DPI), and the impetus is still continuing with the proposed agricultural support services programme (Charles 1982; Papua New Guinea Agricultural Support Services Project 1983).

The role of agricultural research in providing policy guidelines for the long term development plans of the government, and for developing production technologies suitable to the farmer, has been recognised in Papua New Guinea (International Service for National Agricultural Research 1982). Agronomic research that deals with crop husbandry is an important and major component of research in agriculture. The DPI is the main institution in the country responsible for agronomic research. Other institutions such as the universities, Wau Ecology Institute and Christian missions also contribute to research, but their role is minor. A detailed description of the research capability on crops, both food and tree crops, has been given by the International Service for National Agricultural Research (1982).

This paper reviews the past work on food crop research, the impact of this research on the village farmer, and the constraints associated with crop research. It also considers future possibilities for improving research efforts. The focus is on crop agronomy, and the development of viable farm packages suitable for both the subsistence and the commercial farmer. This review is by no means comprehensive and is intended to generate further discussion that will aid future research plans and programmes.

**FOOD CROP RESEARCH: AN OVERVIEW**

Traditional agriculture in Papua New Guinea is dominated by the production of starchy staple crops, and is noted for its diversity (Macewan 1978; Kesavan 1983). Research on these cropping systems commenced relatively recently. However, a large number of agronomic studies have been carried out on food crops in Papua New Guinea. Bourke (1982a) has provided information on these field trials for the fifty year period from 1928. A summary of these trials is given in Table 1. Some of the major points to note are given below.

1. A total of 1230 trials on 77 crop species have been carried out. This amounts to 25 trials per annum or 17.5 trials per person in the 50 year period, taking the scientific manpower as 70, as given by the International Service for National Agricultural Research (1982).

2. Of the 1230 trials, 693 (56 per cent) were variety trials for identifying agronomically superior planting materials. Other agronomic aspects such as fertiliser use, plant density, propagation techniques and pest control were also investigated.

3. Major groups of crops investigated, in terms of numbers of trials, were cereal grains with a large body of work on rice, traditional staples, grain legumes with emphasis on peanuts, and introduced vegetables.
<table>
<thead>
<tr>
<th>Major group of crops</th>
<th>No. of trials</th>
<th>% of total</th>
<th>No. of cv¹ trials</th>
<th>% of major group</th>
<th>Major crop</th>
<th>No. of trials</th>
<th>% of total trials</th>
<th>% of major group</th>
<th>No. of cv¹ trials</th>
<th>% of major crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy and staple crops</td>
<td>286</td>
<td>23.3</td>
<td>94</td>
<td>32.9</td>
<td>Sweet potato</td>
<td>136</td>
<td>11.1</td>
<td>47.5</td>
<td>39</td>
<td>28.7</td>
</tr>
<tr>
<td>Cereals</td>
<td>349</td>
<td>28.4</td>
<td>214</td>
<td>61.3</td>
<td>Rice</td>
<td>234</td>
<td>19.0</td>
<td>67.1</td>
<td>142</td>
<td>60.7</td>
</tr>
<tr>
<td>Grain legumes</td>
<td>245</td>
<td>19.9</td>
<td>155</td>
<td>63.3</td>
<td>Peanuts</td>
<td>91</td>
<td>7.4</td>
<td>37.1</td>
<td>26</td>
<td>28.5</td>
</tr>
<tr>
<td>Fruits and nuts</td>
<td>66</td>
<td>5.4</td>
<td>33</td>
<td>50.0</td>
<td>Pineapple</td>
<td>14</td>
<td>1.1</td>
<td>21.2</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Vegetables, traditional</td>
<td>16</td>
<td>1.3</td>
<td>14</td>
<td>87.5</td>
<td>Setaria</td>
<td>5</td>
<td>0.4</td>
<td>31.3</td>
<td>4</td>
<td>80.0</td>
</tr>
<tr>
<td>Vegetables, introduced</td>
<td>238</td>
<td>19.3</td>
<td>183</td>
<td>76.9</td>
<td>Cabbage</td>
<td>47</td>
<td>3.8</td>
<td>19.7</td>
<td>23</td>
<td>48.9</td>
</tr>
<tr>
<td>Farming systems</td>
<td>30</td>
<td>2.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1230</td>
<td>100.0</td>
<td>693</td>
<td>56.3</td>
<td></td>
<td>527</td>
<td>42.8</td>
<td></td>
<td>234</td>
<td>44.4</td>
</tr>
</tbody>
</table>

¹Cultivar.

Note: coconut, an important source of food, is not included. Source: Bourke (1982a).
4. The work on traditional staples has deservedly concentrated on sweet potato which accounts for 11 per cent of trial work. This work is considered in the next section.

5. The research work on farming or cropping systems started recently and comprises 2.4 per cent of the trials. One of the notable series of experiments was a long term rotation trial at Keravat from 1954 to 1973. Bourke (1977) examined the results and concluded that, without the addition of fertilisers, none of the rotations tested has provided a satisfactory alternative to the bush fallow rotations of subsistence farming.

6. The publication record of research work is considered to be "scandalously low" by Bourke (1978). Of the 1200 or so trials, results from only 230 (19 per cent) have been published. The situation, it appears, has improved in the recent past.

RESEARCH WORK ON SWEET POTATO

Undoubtedly sweet potato is the major crop in the country. It was introduced to Papua New Guinea some 400 years ago, and has attained a place of prominence in the highlands, supplying 60-90 per cent of the energy needs of highlanders. This crop is slowly replacing traditional staples such as Colocasia taro in the lowlands due to its superior adaptability. The past research effort on sweet potato is examined briefly below.

An excellent review of sweet potato, including the research work in Papua New Guinea that has gone into its improvement, is given by Bourke (1982b) who also estimates the value of the crop at K150 million per annum. Bourke's (1982b) Table 2 provides a summary of agronomic work carried out on this crop. The general picture is that the research has been concentrated on fertiliser use and cultivar trials, and the publication record has been poor. Some of the selected cultivars have been accepted by the traditional farmer. However, the benefit of fertiliser studies (which accounts for 30 per cent of the work) is yet to be exploited, since the traditional farmer has not accepted its use or is unable to afford the extra costs involved. Returns to labour could be a serious limiting factor to the use of organic wastes and manures.

Sweet potato has enormous potential for increased production through intensive farming. The recent debate on developing commercial production of sweet potato and other staples (Bourke et al. 1983) indicates the need to look at broader economic and social factors, beyond the development of production technologies. The need for collaborative research, with inputs from agricultural economists, is also evident.

SYSTEMS APPROACH TO RESEARCH

In the past, research work was on individual crops and on major problems affecting the productivity of crops. Inter-disciplinary collaboration and a team
approach to problem solving was minimal or absent in Papua New Guinea. With the establishment of international research institutes, in particular the International Rice Research Institute in the Philippines, an alternative approach to research has been developed. This approach, known by the terms ‘cropping systems’ or ‘farming systems’, analyses biophysical, social and economic constraints to productivity at a given site or farm, with a view to developing techniques for increased crop production or cropping intensity (Zandstra et al. 1981). This is an extension of the old ideas of multi-disciplinary team research with the inclusion of the crucial component of on-farm evaluation and validation at the farmer’s level of management (see Figure 1).

The concept of a systems approach is theoretically appealing, but to put it into practice requires considerable resources and trained manpower. Traditional agriculture in Papua New Guinea involves highly complex systems which have evolved to suit specific agricultural and social environments. They therefore constitute enormous diversity (Macewan 1978). A recent review of subsistence production systems is given by Kesavan (1983) who has also indicated that the cropping systems approach can be used for research on the complex problems of Papua New Guinea agriculture. The idea of multi-disciplinary research has been accepted in principle by DPI based on the review by the International Service for National Agricultural Research (1982).

Currently these ideas are being debated by researchers both within and outside DPI, and the reorganisation that is taking place in DPI (Charles 1991) aims to incorporate some of these ideas. One successful application of a team approach has been the work on the Nembi Plateau in the Southern Highlands (Bourke and D’Souza 1982; D’Souza and Bourke 1983). Suitable cultivars of sweet potato, and component technologies such as composting, have been identified, and accepted by the people of the plateau. A recent review of the work of AFTSEMU (Agricultural Field Trials, Studies, Extension and Monitoring Unit), a component of the Southern Highlands Rural Development Project (SHRDP), however, has indicated that there has been little or no follow up work. With the expected termination of the project, the whole research and extension effort may come to an end (Lea and Goie 1983). This is a sad state of affairs and exemplifies the critical role to be played by establishing proper links between research and extension.

IMPACT OF FOOD CROP RESEARCH

It is clear that agronomic research in the past has ranged far and wide. The emphasis on rice and introduced vegetables reflects the concern to reduce imports and to satisfy the growing needs of urban and institutional consumers. The various monocrop agronomy trials conducted at the agricultural experiment stations do not reflect the mixed planting and polyculture of subsistence gardens. The large body of variety trials may have indeed identified superior varieties, but in the absence of published records and adaptive on-farm trials such as that of the work on the Nembi Plateau, the impact of selected varieties on Papua New Guinea agriculture is difficult to evaluate. The same conclusion applies for other agronomic studies.
Low Intensification potential

Other strategies: resettlement, cash cropping, urban employment

Component technology development and evaluation (Research Stations)

Selection of sites

High

Site description

Improved cropping systems

On-farm testing of cropping system

Preproduction evaluation

Production programmes

Integration with farming system

Figure 1. Components of cropping system research (after Zandstra et al. 1981).
Overall, the impact of past research on food crops has been minimal. The notable exceptions are peanuts, maize and a few cultivars of sweet potato that have been accepted by the traditional farmer. Various other reviews and consultancies (see for example Gamble et al. 1981; International Service for National Agricultural Research 1982; United Nations Development Project 1983) have identified constraints associated with research and have made recommendations to improve the situation.

The major causes for the poor impact are listed below.

1. There is a lack of suitable farm packages arising from research. This is largely attributable to organisational and managerial constraints at the research direction level, and the inadequacy of trained manpower at all levels of research.

2. There are poor links between the researcher and the farmer through extension staff.

FUTURE PROSPECTS

Food crop research has received increased attention in the last decade. The various subsistence production systems are complex. However, the sweet potato-based highland systems are relatively well understood compared to the taro-, banana- and yam-based lowland systems (see for example Macewan 1978; Kesavan 1983). More work is needed to understand the existing systems of production, and the factors that are likely to improve productivity. Where there is potential for intensification, such as areas with land pressure in the highlands and East New Britain Province, researchers have the challenge to develop viable and acceptable component technologies. Some approaches to research that will meet the challenge are given below.

1. The foremost task is reorganisation of research. This is already being undertaken (Charles 1991), and will provide central direction and coordination. A major task is to determine priorities so that research gets a policy focus and avoids dilution of resources.

2. Identification of crops and systems that require immediate research attention is necessary. It is clear that sweet potato-based highland systems deserve priority. The task is more complex for the lowland crops and cropping systems. Continued discussion to arrive at priorities is essential. The current discussions on crop research priorities at the Lowlands Agricultural Experiment Station, Keravat (Sitapai 1983) are timely and welcome. It is hoped that discussions during this conference will clarify issues further.

3. It is desirable to use a systems approach with suitable modifications, but this approach requires large inputs both in terms of finance and trained manpower. However, it will be successful in the development of acceptable innovations.
4. The development of component technologies suitable for both subsistence and commercial producers, and their integration into existing production practices, is necessary.

5. Once suitable alternative systems are identified by research, these have to be evaluated at the farmer's level of management. Clearly, this requires an enlightened extension service. This link is the crucial one. Imaginative improved pre-service and in-service training of extension personnel is warranted.

6. Integration of crop research efforts with extension, and other institutions and disciplines such as economics, livestock and fisheries is also essential. One area that deserves research priority is the emerging cash crop and food crop combinations and the inherent competition associated with their interactions.

7. Last but not the least, I would like to make a plea for increased use of plant breeding techniques for crop improvement.

I would like to conclude this discussion with an evolutionary note. Papua New Guinea farmers have accepted changes that are suitable for them, and the cropping systems do require change. The challenge facing food crop scientists is to facilitate this change.

REFERENCES


SOYBEAN WORK IN THE MARKHAM AND RAMU VALLEYS OF PAPUA NEW GUINEA

Rosa N. Kambuou

Agriculture Research Centre, Bubia, Lae, Morobe Province

ABSTRACT

Research work on soybean (Glycine max) was initiated by the Department of Primary Industry (DPI) some years ago. Soybean was considered to be a useful grain legume for protein supplement in stockfeed. It was selected because of its agronomic advantages over other grain legumes; in addition, the dried seeds contain 30-40 per cent protein and 16-21 per cent oil. Apart from its use as a protein supplement in feed, soybean is a cheap and excellent source of protein for the kitchen table if properly cooked or processed.

Altogether 136 soybean lines were introduced from Queensland and Taiwan. The varieties 'Ross', 'Daintree', 'Gilbert', 'Improved Pelican', '71-39' and 'K39' are currently released for planting. An average experimental yield of these varieties is approximately 2.5 tonnes per hectare.

To obtain optimum yield, a population of 350,000 - 400,000 plants per hectare is necessary. A row spacing of 70 cm is recommended. However narrower spacings are encouraged if pre-emergent weedicides are used for weed control.

Weedicide studies have shown that treflan (trifluraline) at 2.1 L product per hectare will control grass weeds, particularly Rottboellia exaltata, which is a common annual grass in cultivated areas of the Markham and Ramu Valleys.

INTRODUCTION

Soybean (Glycine max) is a member of an important group of vegetables called pulses or food legumes. It has been variously referred to as the miracle golden bean, pearls of the orient, the cow of China, the meat of the field, the meat that grows on vines and the protein hope of the future. Regardless of what it is called, soybean is a promising and proven source of plant protein and edible oil.
Very few pulses have been traditionally cultivated for food in Papua New Guinea. The main sources of protein have been from wild animals, birds and fish. In recent years there has been an organised effort by the Government to improve and increase the protein intake in areas which are low in protein production. Cultivation and production of pulses for food in the country is very low at present since most species of pulses currently being cultivated were introduced from overseas and therefore are uncommon as food amongst the indigenous population.

Although soybean is an old crop in the Far East and a highly successful modern-day crop in the United States of America and Brazil, it is considered a "new" and largely unproven crop in many regions of the world, particularly in tropical countries such as Papua New Guinea. A move to increase soybean production will require the introduction of new technology and a well-founded educational programme on utilisation of the crop.

Soybean has been in the Markham and Ramu Valleys since 1963, but the Department of Primary Industry's formal research work started in the early seventies. There were two categories of soybeans: the "determinate types" and the "indeterminate types". The determinate varieties produce flowers on the terminal buds which in turn prevent the growth of the main stems. Most of the commercial varieties are in this category. The indeterminate varieties do not produce flowers on terminal buds, rather the flowers are produced laterally and successively as the stem elongates. Seed colour, size and shape varies between varieties. The stockfeed industry prefers creamy or yellow seeds.

The protein and oil content of seeds also varies with variety (see Table 1).

<table>
<thead>
<tr>
<th>Soybean variety</th>
<th>Moisture</th>
<th>Fat</th>
<th>Protein</th>
<th>Ash value</th>
</tr>
</thead>
<tbody>
<tr>
<td>71 - 39</td>
<td>12.00</td>
<td>19.30</td>
<td>32.20</td>
<td>5.70</td>
</tr>
<tr>
<td>Improved Pelican</td>
<td>15.05</td>
<td>23.00</td>
<td>36.10</td>
<td>5.10</td>
</tr>
<tr>
<td>Ross</td>
<td>15.50</td>
<td>19.40</td>
<td>36.20</td>
<td>5.70</td>
</tr>
<tr>
<td>Gilbert</td>
<td>10.70</td>
<td>18.30</td>
<td>34.80</td>
<td>5.68</td>
</tr>
<tr>
<td>Daintree</td>
<td>12.55</td>
<td>18.30</td>
<td>36.30</td>
<td>5.81</td>
</tr>
<tr>
<td></td>
<td>14.30</td>
<td>14.20</td>
<td>36.40</td>
<td>5.75</td>
</tr>
</tbody>
</table>

**RESEARCH PROGRAMMES**

The primary objective of soybean research by DPI in the country is to identify suitable tropical lowland varieties that can be produced locally for protein, for the rural diet where animal protein is scarce. The formal research programmes undertaken in the Markham and Ramu Valleys are discussed below.
RESULTS

The most important selection criteria in these trials were mean fruit weight, yield, a determinate vine type, and resistance to bacterial wilt. In some trials, the tolerance of varieties to leaf diseases and other pathogens was also assessed.

New varieties were screened as they were obtained. Promising varieties were included in further trials, and unsuitable lines were discarded.

Results with Open Pollinated Lines

During the nine years of trials, 307 accessions were obtained from more than six tropical countries. These accessions are listed in Table 2.

Many of the accessions were determinate and had resistance to bacterial wilt. However in general, fruit size was small (less than 50 g). Yields varied widely between trials and varieties, but for the better varieties, they were usually in the range of 2 to 4 kg per plant. This is equivalent to 25 to 50 t/ha.

Blackburn (1979) selected one line ('NG 7536') originating from the Asian Vegetable Research and Development Centre in Taiwan as performing best in the early trials. This determinate variety is heat tolerant, large fruited (c. 100 g) and resistant to bacterial wilt. However fruit quality and firmness tend to be poor. In subsequent trials, 'Vuavina' has performed as well as 'NG 7536'. Where bacterial wilt does not occur, 'Walter Improved' gives very high quality fruit.

Results with F1 Hybrids

One trial conducted in 1981 contained several F1 hybrids and their parent lines. These had been produced by Yates Seed Company (New Zealand). The hybrids showed significant improvement over their parent lines for some attributes.

Table 1. The important variety selection characters for tomatoes in the tropical lowlands.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>The plant should be determinate and heat tolerant.</td>
</tr>
<tr>
<td>2.</td>
<td>The plant should be resistant to bacterial wilt and leaf spots.</td>
</tr>
<tr>
<td>3.</td>
<td>There should be a good yield of usable fruits, with a mean fruit weight of about 100 grams.</td>
</tr>
<tr>
<td>4.</td>
<td>The fruit should be of good quality: firm, with good flavour.</td>
</tr>
</tbody>
</table>
As a result of this trial, six parent lines which each had a number of desirable characteristics were chosen and crossed in all combinations. All the varieties had at least one undesirable characteristic. The attributes of these parent lines are shown in Table 3.

These F1 hybrid seed lines were evaluated during the wet season when susceptibility to bacterial wilt is greatest. It was found that good bacterial wilt resistance and good fruit size is required in both parents. Indeterminate vine growth is dominant, thus both parents must be determinate in order to produce a determinate F1 hybrid. However heterosis for yield was demonstrated. Crosses had on average higher yields than either of the parent lines. Also, overall, the fruit quality of the crosses was superior to that of the parent lines.

Table 2. Origin of tomato accessions evaluated in trials at Laloki Horticultural Research Station.

<table>
<thead>
<tr>
<th>Origin</th>
<th>Number of accessions</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Philippines¹</td>
<td>9</td>
<td>Obtained through Redlands Horticultural Research Station, Queensland.</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>Obtained through Yates Research, New Zealand.</td>
</tr>
<tr>
<td>AVRDC²</td>
<td>7</td>
<td>Parent lines.</td>
</tr>
<tr>
<td>Taiwan</td>
<td>234</td>
<td>AVRDC crosses.</td>
</tr>
<tr>
<td>New Zealand</td>
<td>2</td>
<td>Yates Research.</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>Bacterial wilt resistant lines collected from several sources.</td>
</tr>
<tr>
<td>South Africa</td>
<td>4</td>
<td>Breeding lines from H.R.I., Pretoria.</td>
</tr>
<tr>
<td>Nigeria</td>
<td>4</td>
<td>Varieties from IITA.</td>
</tr>
<tr>
<td>Thailand</td>
<td>3</td>
<td>Varieties from the Chiangmai University evaluation programme.</td>
</tr>
<tr>
<td>Commercial</td>
<td>11</td>
<td>Open pollinated.</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>F1 hybrids.</td>
</tr>
</tbody>
</table>

¹Philippines origin of 7 per cent of total accessions.
²AVRDC origin of 76 per cent of total accessions.
CONCLUSION

The tomato variety evaluation programme at Laloki has produced a widely used lowland tomato variety ('NG 7536') for Papua New Guinea. In addition, other varieties with some desirable attributes have been found.

The initial results with F1 hybrids have been promising, and a further trial is in progress.

Also, as a result of these trials, suitable cultural techniques have been developed for growing tomatoes in the lowlands. Copies of the recommended cultural techniques, and samples of seed of 'NG 7536' are available on request.

Table 3. Attributes of parent lines used in a tomato diallel cross at Laloki Horticultural Research Station.

<table>
<thead>
<tr>
<th>Tomato line</th>
<th>Bacterial wilt</th>
<th>Vine growth</th>
<th>Yield</th>
<th>Fruit size</th>
<th>Fruit quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walter Improved</td>
<td>S</td>
<td>D</td>
<td>A</td>
<td>L</td>
<td>G</td>
</tr>
<tr>
<td>Floradade</td>
<td>S</td>
<td>D</td>
<td>A</td>
<td>L</td>
<td>G</td>
</tr>
<tr>
<td>Scorpio</td>
<td>MR</td>
<td>I</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>Vuavina</td>
<td>R</td>
<td>D</td>
<td>A</td>
<td>L</td>
<td>A</td>
</tr>
<tr>
<td>19/10A</td>
<td>R</td>
<td>D</td>
<td>H</td>
<td>S</td>
<td>A</td>
</tr>
<tr>
<td>NG 7536</td>
<td>R</td>
<td>D</td>
<td>A</td>
<td>L</td>
<td>P</td>
</tr>
</tbody>
</table>

1S = susceptible; MR = moderately resistant; R = resistant.  
2D = determinate; I = indeterminate.  
3A = average; H = high.  
4L = large (approximately 100 g); A = average (approx. 75 g); S = small (approx. 50 g).  
5G = good; A = average; P = poor.
REFERENCES


SCRENNING OF SWEET POTATOES (IPOMOEA BATATAS (L.) LAM.) IN THE SOUTHERN HIGHLANDS PROVINCE, PAPUA NEW GUINEA

Merle M. Anders

Southern Highlands Rural Development Project, Mendi, Southern Highlands Province

ABSTRACT

In late 1981 the Southern Highlands Rural Development Project initiated a programme to identify yield components of sweet potato (Ipomoea batatas (L.) Lam.) in the subsistence farming system. At the same time, sweet potato cultivars were collected throughout the Province, described, and placed into a polycross nursery. The overall objectives were (1) to determine the practicality of sweet potato breeding using existing cultivars as a source of new cultivars and (2) to develop an effective screening methodology.

Agronomic and plant yield characters are reviewed and results presented for the following: plant density; soil fertility levels; time to maturity; crude protein content; amino acid content; trypsin inhibitor content; dry matter content; and seasonality. From these data a screening system is developed for sweet potato breeding. Performance of seedlings grown from seed collected in a polycross nursery is discussed.

INTRODUCTION

Sweet potato (Ipomoea batatas (L.) Lam.) is the staple food for all areas in the Southern Highlands Province of Papua New Guinea (PNG) above 900 metres above mean sea level (amsl). These areas contain a population of approximately 185,600 people. The cultivation of sweet potato throughout these areas is carried out on a wide range of soils in a wide range of environmental zones. Specific cultivation methods have been described by Bourke (1982). Soils and climate have been described by Rutherford and Perry (1965).

This paper deals with two broad aspects of sweet potato research: firstly, the agronomic and physiological parameters of some Southern Highlands Province cultivars and secondly, the development of a polycross breeding programme, including the determination of protein quality and quantity in the existing genetic base, and the evaluation of newly developed cultivars.
All the agronomic work described in this paper was carried out at Kiburu Research Station, Mendi, Southern Highlands Province. The soil there is generally characterised by a medium to high level of organic matter, low base saturation particularly for potassium (K), extremely low phosphorus (P) levels, high P retention, and high aluminium (Al) saturation in the ‘A’ horizon. Moisture retention analyses indicated a 48.8 per cent and 46.7 per cent moisture retention at 0.1 bar and 0.3 bar respectively. Easily available water (0.1-1 bar) is somewhat low at 7.4 per cent. Rainfall during the planting period indicated a normal distribution pattern except for the period July to November 1982 when a severe drought occurred.

The word ‘roots’ is used in this paper to refer to swollen roots or root tubers.

PART 1: AGRONOMY AND PHYSIOLOGY

A. PLANT DENSITY

INTRODUCTION

Plant density studies which have been completed in Papua New Guinea consist of five trials by A.J. Kimber (personal communication). In these trials individual cultivars were planted on ridges with varied spacings between ridges, and varied distances between plants within a ridge. Densities were varied from 11,100 to 111,100 plants per hectare. In all these trials no significant differences were found in total root yield or marketable root yield. However, there was a significant linear decrease in root size with increasing plant density in all trials.

METHODOLOGY

Two plant density trials were established to evaluate ten plant parameters using various numbers of plants per station (planting point) and various numbers of stations per given mound area.

Trial No. 1

On 3 July 1981 five replications of a sweet potato plant density trial were planted using a randomised complete block design. Five cultivars, ‘Wanmun’, ‘Kariap’, ‘Simbul Sowar’, ‘Seka’ and ‘Merikan’ were randomly distributed among 15 stations according to treatment (See Table 1). The mounds (5.02 m² flat land area) received a pre-plant application of 100 kg N, 22 kg P, and 166 kg K per hectare. Vine cuttings 30 cm in length were used as planting material.

At 90 days after planting (DAP) two independent assessments were made of the percentage of ground covered by the plant canopy. One complete harvest was carried out at seven months after planting. Data were collected on plant number, total fresh top weight, total root number (< 100 g per root), total root weight (<
100 g), total root number (> 100 g), total root weight (> 100 g), and per cent canopy cover at 90 DAP.

**Trial No. 2.**

On 27 August 1981 a second trial was planted using the same mound size, cultivars, fertiliser and management scheme as in Trial No. 1. However, in this trial the number of slips per station was kept constant at three, with the number of stations per mound increased by multiples of five (See Table 1).

**RESULTS AND DISCUSSION**

The results obtained from Trial 1 and Trial 2 are given in Figure 1 and Figure 2.

Total fresh root weight in Trial 1 was significantly (P<0.05) lower for treatment 1 (1 slip/station) than for any other treatment. In Trial 2 no significant differences were found for total fresh root yield between any of the treatments. This total fresh root weight stability was attained by a highly significant (P>0.01) linear decrease in the number of roots per plant with increasing plant population density, which contributed to a highly significant (P<0.01) linear decrease in the fresh root weight per plant with increasing plant population density. The percentage of fresh root yield of roots less than 100 g highly significantly (P<0.01) increased as plant population increased in Trial 1, but showed no significant change in Trial 2. Root to root plus vine fresh weight ratio showed no significant differences between treatments for both Trial 1 and Trial 2. Percentage canopy cover at 90 DAP showed a highly significant (P<0.01) increase with increasing plant population density.

**Table 1.** Number of slips per station (Trial No. 1), stations/mound (Trial No. 2), and plants per hectare, for two sweet potato experiments in the Southern Highlands Province.

<table>
<thead>
<tr>
<th>Slips per station</th>
<th>Plants per ha (x 1000)</th>
<th>Plants per ha</th>
<th>Plants per ha (x 1000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>29.9</td>
<td>10</td>
<td>59.8</td>
</tr>
<tr>
<td>2</td>
<td>59.8</td>
<td>15</td>
<td>89.7</td>
</tr>
<tr>
<td>3</td>
<td>89.7</td>
<td>20</td>
<td>119.6</td>
</tr>
<tr>
<td>4</td>
<td>119.6</td>
<td>25</td>
<td>149.5</td>
</tr>
<tr>
<td>5</td>
<td>149.5</td>
<td>30</td>
<td>179.4</td>
</tr>
</tbody>
</table>
Figure 1. Graphs showing the effects of sweet potato plant population density on (A) fresh root weight (kg/5.02 m² plot); (B) number of roots per 5.02 m² plot; (C) mean root weight (kg); (D) vine fresh weight (kg/5.02 m² plot); (E) number of roots per plant; and (F) percentage of total yield that is roots less than 100 g in weight, for two planting systems used in Trial Nos. 1 and 2. (See text for details of planting methods.)
Figure 2. Graphs showing the effects of sweet potato plant population density on (A) fresh root weight per plant (kg); (B) weight ratio of root to root plus vine fresh weight; and (C) percentage canopy cover at 90 days after planting, for two planting systems used in Trial Nos. 1 and 2. (See text for details of planting methods.)
B. SOIL FERTILITY

INTRODUCTION

Bourke (1982) stated that "over 50 inorganic and organic fertiliser trials have been carried out on sweet potato in Papua New Guinea, many of them in the highlands." He pointed out, however, that results from the use of inorganic fertiliser are inconsistent, with occasional responses to potassium and nitrogen. This inconsistency is attributed to varying soil types and differences in cultivar responses.

Tsuno and Fujise (1968a, b), in their studies on sweet potato dry matter production, documented the importance of potassium in root enlargement. In the Southern Highlands Province, the volcanic ash soils generally contain marginal amounts of potassium, and medium to high levels of nitrogen.

TRIAL NO. 3

Methods

On 22 October 1981, three replications of a non-factorial experiment comprising N, P, K, trace element and furadan treatments were planted. Plantings were made into 5.0 m² mounds using five cultivars. Treatment details are given in Table 2. Each mound contained 15 planting stations with three randomly selected slips placed into each station. Fertilisers and nematicides were incorporated into the mounds prior to planting. Leaf samples were collected for chemical analysis from each mound at four months after planting. A complete harvest was carried out at seven months after planting.

Results and Discussion

Fresh yields for the various treatments are presented in Table 2. Despite a yield range from 36.92 t/ha to 66.00 t/ha no significant differences existed between single element treatments. Although the results indicated a potential potassium response, the rates were possibly too low in relation to the high nitrogen levels in the soil.

TRIAL NO. 4

Methods

On 20 January 1983, a completely randomised NPK factorial fertiliser trial was planted. Five cultivars were randomly planted at 15 stations on each 2.5 m² mound. Fertilisers were incorporated into the mounds prior to planting. The mounds were harvested at six months after planting. The treatments were: N (0 and 100 kg N/ha), P (0 and 44 kg P/ha), and K (0, 83, 166 and 332 kg K/ha).
Data was collected on fresh root, dry root and fresh top weights, number of roots less than 100 g, number of roots greater than 100 g, root weight of tubers less than 100 g, root weight of tubers greater than 100 g, and monthly rainfall from one month prior to planting to the time of harvest.

RESULTS AND DISCUSSION

This trial was still in progress at the time of writing and thus the results presented here will be for the planting period from 15 July 1981 to 15 December 1982. Total fresh root weight and total root numbers by planting date are given in Figure 5. The correlation coefficient (r) for these two plant characters was 0.83. Other correlation coefficients for plant characters measured during this period were:

- total fresh root yield with total fresh vine weight, $r = 0.49$;
- total root numbers with mean root weight, $r = 0.02$;
- total root numbers with total vine fresh weight, $r = 0.35$.

These values indicate a strong positive correlation between yield and root number.

Wilson (1982), in summarising his earlier work with sweet potato, divided the tuberisation process into (1) a period of tuber initiation up to week 8; (2) a linear phase of rapid bulking during weeks 8-12; and (3) a phase of late tuber bulking from week 12 onwards.

From the work presented here it would appear that the changes in yield over the plantings may have been correlated with rainfall early in the plant's life. Correlation coefficients for fresh root weight with rainfall, over the ten cultivars studied were as follows:

- Planting - 1 month: 0.5902 **
- 1st month growth: 0.4741 *
- 2nd month growth: 0.4413 NS
- 3rd month growth: 0.4220 NS
- 4th month growth: 0.5899 **
- 5th month growth: 0.3539 NS
- 6th month growth: 0.2455 NS
- 7th month growth: 0.0932 NS

(* = statistically significant (P<0.05); ** = highly statistically significant (P<0.01); and NS = not statistically significant).

It is necessary to realise that the above results are an average value for ten cultivars. Individual cultivars which mature early and are characterised by large root numbers show much higher correlation in the early growth stages. No trends were noted for the correlations of total vine fresh weight with rainfall. Small negative correlations for rainfall with the ratio of root weight to root plus vine weight were found in months 4, 5 and 7. It was also noted that within individual plantings the ranking of cultivars changed little except during a drought period.
Figure 5. Graphs showing seasonality of fresh root yield (kg per plot of 10 plants on a 3 m ridge) and number of tubers per plot for monthly harvests from July 1981 to December 1982. Plotted points are averages of 10 cultivars and three replicates per cultivar. (See text for details of cultivars.)
These changes can be explained by the different correlations of yield with rainfall in a given month when comparing individual cultivars. Of all the plant characters studied, the ratio of root to root plus vine fresh weight remained the most stable throughout all plantings.

**PART 2: BREEDING AND EVALUATION**

**A: BREEDING**

The concept of a polycross sweet potato breeding programme occurred spontaneously in the Southern Highlands Province. In many areas, cultivars flower freely and develop seeds which give rise to new cultivars. Many farmers recognise the potential of these new cultivars. At the village level, slips are collected from seedlings and incorporated into the normal planting system. This "direct" evaluation accounts for a large and rapid turnover of germplasm in some areas. It also allows for rapid introduction and village level evaluation of a large number of cultivars.

In 1981, a collection of sweet potato cultivars found in the Southern Highlands Province commenced. In order to accurately index these cultivars on the IBPGR descriptor sheets (International Board for Plant Genetic Resources 1981), all cultivars were trellised. It was then noted that a large percentage of the accessions flowered and produced seed. Following the collection of adequate seed numbers, the established cultivar screening trials were expanded to include seed cultivars selected from outstanding parents. The performance of some of these selections is described below. With the collection of nearly 40,000 seeds it has become extremely important to describe the parameters of the existing genetic population and establish stringent guidelines for screening.

In the Southern Highlands Province, sweet potato represents the staple food for 80 per cent of the population. The quantity and quality of protein contained in the sweet potato thus becomes an important factor in the breeding and screening programme.

Reports by Bradbury et al. (1983a, b) contain information on the protein quantity and quality of selected cultivars from the Southern Highlands Province. A summary of the results is given in Table 4.

Despite the relatively small number of cultivars which have been studied in relation to the total gene pool available in Papua New Guinea, these results indicate great potential for the selection of high yielding cultivars with improved protein quantity and quality. The correlation coefficients for protein quantity and quality and plant yield characters are sufficiently low to allow for the development of cultivars better suited for the role they must play in subsistence agriculture.
Table 4. Summary of chemical analysis data for selected cultivars from the Southern Highlands Province.

<table>
<thead>
<tr>
<th>Character</th>
<th>High</th>
<th>Low</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen in dried root tuber (per cent)</td>
<td>1.25</td>
<td>0.25</td>
<td>0.75</td>
</tr>
<tr>
<td>Crude protein in dried tuber (per cent)</td>
<td>3.83</td>
<td>0.38</td>
<td>2.11</td>
</tr>
<tr>
<td>Dry matter (per cent)</td>
<td>43.00</td>
<td>26.00</td>
<td>35.00</td>
</tr>
<tr>
<td>Trypsin Inhibitor (Units/gram)</td>
<td>43.6</td>
<td>0.26</td>
<td>21.93</td>
</tr>
</tbody>
</table>

Notes:

1. Frequency of limiting amino acids: Lysine 35%  
   Leucine 31%  
   S-containing amino acids 17%

2. Correlation coefficients for crude protein (%) with trypsin inhibitor (Units/g) for individual cultivars over five plantings:
   Mean: 0.71; range 0.46 - 0.96.

3. Correlation coefficients for crude protein (%) with trypsin inhibitor (Units/g) between cultivars at individual planting sites and times:
   Mean: 0.49; range 0.15 - 0.83.

4. Correlation coefficients for nitrogen percentage in dry roots with root dry matter percentage between varieties at different planting times and locations:
   Mean: 0.05.

5. Correlation coefficients for nitrogen percentage in dry roots with root dry matter percentage between individual cultivars over four plantings:
   Mean: 0.64; range: 0.29 - 0.98.

6. Correlation coefficients for nitrogen percentage in dry roots with root dry matter percentage between cultivars at individual planting sites and times:
   Mean: 0.23; range: 0.005 - 0.46.
Results and Discussion

Results for total tuber dry weight yields are presented in Table 10. For all cultivars there was an increase in yield with increasing plant population density. The differences between the percentages gained by each cultivar demonstrates competitiveness.

Table 9. Summary of sweep potato cultivar evaluation for root/root-plus-vine fresh weight ratio in Trial No. 7. (See text for details of the experimental design.)

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Late harvest (7 months)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 slip per set</td>
<td>4 slips per set</td>
<td>% Change</td>
<td></td>
</tr>
<tr>
<td>Mamme</td>
<td>0.72</td>
<td>0.71</td>
<td>-1</td>
<td></td>
</tr>
<tr>
<td>Goroka</td>
<td>0.31</td>
<td>0.30</td>
<td>-3</td>
<td></td>
</tr>
<tr>
<td>Marshall</td>
<td>0.79</td>
<td>0.70</td>
<td>-11</td>
<td></td>
</tr>
<tr>
<td>K Wanmun</td>
<td>0.65</td>
<td>0.64</td>
<td>-2</td>
<td></td>
</tr>
<tr>
<td>S Munduwana</td>
<td>0.45</td>
<td>0.55</td>
<td>+22</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Late harvest (7 months)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low fertility</td>
<td>Medium fertility</td>
<td>High fertility</td>
<td></td>
</tr>
<tr>
<td>Mamme</td>
<td>0.76</td>
<td>0.74</td>
<td>0.65</td>
<td></td>
</tr>
<tr>
<td>Goroka</td>
<td>0.26</td>
<td>0.32</td>
<td>0.35</td>
<td></td>
</tr>
<tr>
<td>Marshall</td>
<td>0.73</td>
<td>0.71</td>
<td>0.80</td>
<td></td>
</tr>
<tr>
<td>K Wanmun</td>
<td>0.64</td>
<td>0.59</td>
<td>0.71</td>
<td></td>
</tr>
<tr>
<td>S Munduwana</td>
<td>0.50</td>
<td>0.52</td>
<td>0.49</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Early harvest (5 months)</th>
<th>Late harvest (7 months)</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mamme</td>
<td>0.57</td>
<td>0.72</td>
<td>+26</td>
</tr>
<tr>
<td>Goroka</td>
<td>0.18</td>
<td>0.31</td>
<td>+72</td>
</tr>
<tr>
<td>Marshall</td>
<td>0.62</td>
<td>0.75</td>
<td>+21</td>
</tr>
<tr>
<td>K Wanmun</td>
<td>0.44</td>
<td>0.65</td>
<td>+48</td>
</tr>
<tr>
<td>S Munduwana</td>
<td>0.40</td>
<td>0.50</td>
<td>+25</td>
</tr>
</tbody>
</table>
Cultivar 'K14' is a half sibling of 'Mamme', and both cultivars show a low degree of competitiveness. As for Trial No. 7, no yield trends were evident for varying soil fertility levels. All cultivars recorded large yield gains at the later harvest compared to the early harvest, thus indicating that a large amount of bulking was taking place in the period from 4 months after planting (MAP) to 6 MAP. The largest gain in yield during this period was recorded for 'K14', even though this cultivar appeared to be less competitive.

Table 10. Tuber dry weight yield (kg per 6.25 m² plot) for five sweet potato cultivars in Trial No. 8 (see text for details).

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Late harvest (6 months)</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 slip per set</td>
<td>4 slips per set</td>
</tr>
<tr>
<td>Mamme</td>
<td>1.36</td>
<td>1.77</td>
</tr>
<tr>
<td>Wanmune</td>
<td>1.31</td>
<td>2.92</td>
</tr>
<tr>
<td>K1</td>
<td>1.51</td>
<td>2.59</td>
</tr>
<tr>
<td>K6</td>
<td>1.30</td>
<td>2.58</td>
</tr>
<tr>
<td>K14</td>
<td>1.64</td>
<td>1.71</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Late harvest (6 months)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low fertility</td>
<td>Medium fertility</td>
</tr>
<tr>
<td>Mamme</td>
<td>1.09</td>
<td>1.18</td>
</tr>
<tr>
<td>Wanmune</td>
<td>1.29</td>
<td>1.34</td>
</tr>
<tr>
<td>K1</td>
<td>1.23</td>
<td>1.23</td>
</tr>
<tr>
<td>K6</td>
<td>1.57</td>
<td>1.19</td>
</tr>
<tr>
<td>K14</td>
<td>1.18</td>
<td>1.26</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Early harvest (4 months)</th>
<th>Late harvest (6 months)</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mamme</td>
<td>1.54</td>
<td>3.13</td>
<td>+203</td>
</tr>
<tr>
<td>Wanmune</td>
<td>2.02</td>
<td>4.22</td>
<td>+209</td>
</tr>
<tr>
<td>K1</td>
<td>2.56</td>
<td>4.10</td>
<td>+160</td>
</tr>
<tr>
<td>K6</td>
<td>2.13</td>
<td>3.88</td>
<td>+182</td>
</tr>
<tr>
<td>K14</td>
<td>1.46</td>
<td>3.34</td>
<td>+229</td>
</tr>
</tbody>
</table>
TRIAL NO. 9

Methods

On 10 March 1983, a cultivar evaluation trial was planted using the previously described design (for Trial No. 7), but altering the harvest time to 4 and 7 months from planting. The cultivars used in the trial were ‘Wanmun’, ‘Mamme’, ‘K2’, ‘K12’ and ‘K13’. Cultivars ‘K2’, ‘K12’, and ‘K13’ were selections from the polycross nursery. No preliminary evaluations were carried out on these cultivars.

Table 11. Tuber dry weight yield (kg per 6.25 m² plot) for five sweet potato cultivars evaluated in Trial No. 9. (See text for details of the experimental design.)

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Late harvest (7 months)</th>
<th>1 slip per set</th>
<th>4 slips per set</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mamme</td>
<td></td>
<td>0.21</td>
<td>0.23</td>
<td>+9</td>
</tr>
<tr>
<td>Wanmun</td>
<td></td>
<td>0.49</td>
<td>0.61</td>
<td>+25</td>
</tr>
<tr>
<td>K2</td>
<td></td>
<td>1.04</td>
<td>1.87</td>
<td>+79</td>
</tr>
<tr>
<td>K12</td>
<td></td>
<td>0.15</td>
<td>0.14</td>
<td>-2</td>
</tr>
<tr>
<td>K13</td>
<td></td>
<td>0.09</td>
<td>0.17</td>
<td>+89</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Late harvest (7 months)</th>
<th>Low fertility</th>
<th>Medium fertility</th>
<th>High fertility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mamme</td>
<td></td>
<td>0.33</td>
<td>0.14</td>
<td>0.18</td>
</tr>
<tr>
<td>Wanmun</td>
<td></td>
<td>0.56</td>
<td>0.49</td>
<td>0.59</td>
</tr>
<tr>
<td>K2</td>
<td></td>
<td>1.42</td>
<td>1.32</td>
<td>1.62</td>
</tr>
<tr>
<td>K12</td>
<td></td>
<td>0.15</td>
<td>0.14</td>
<td>0.15</td>
</tr>
<tr>
<td>K13</td>
<td></td>
<td>0.16</td>
<td>0.09</td>
<td>0.14</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Early harvest (4 months) Late harvest (7 months) % Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mamme</td>
<td>0.04 0.22 +550</td>
</tr>
<tr>
<td>Wanmun</td>
<td>0.19 0.55 +289</td>
</tr>
<tr>
<td>K2</td>
<td>1.42 1.45 +302</td>
</tr>
<tr>
<td>K12</td>
<td>0.15 0.14 +280</td>
</tr>
<tr>
<td>K13</td>
<td>0.16 0.13 +216</td>
</tr>
</tbody>
</table>
Results and Discussion

Results of total tuber dry weight yield are summarised in Table 11. None of the cultivars tested proved to be extremely competitive when comparing low and high plant densities. Cultivar ‘K13’ had the greatest percentage increase in yield for high population density compared to low population density. However the mean yields of this cultivar were lower than those for the other cultivars tested. No trends were evident with changing fertility. In comparing early and late harvests, the cultivar ‘Mamme’ had the largest increase in dry root yield, yet it ranked third for total yield at the late harvest. Cultivar ‘K2’ which ranked second for yield increase had the highest yield at both harvest dates.

In reviewing the performance of the above cultivars with respect to total root numbers, it was noted that ‘K2’ averaged 9.04 and 5.07 roots/plant respectively for low and high density plantings. A high number of roots per plant is extremely desirable for a multiple harvest system. This characteristic, together with a 35 per cent root dry matter and individual mound yields of 51 t/ha at 7 MAP, makes ‘K2’ a most promising cultivar.

CONCLUSION RELATING TO EXPERIMENTAL DESIGN

From the three cultivar screening trials presented in this paper it was considered that a trial design which could be statistically analyzed would be preferable. This design would need to cover plant character variables which indicate cultivar acceptance at village level. With the assistance of Mr. David Moles, Biometrician, Department of Primary Industry, the design indicated below was developed.

Design: Split block

Treatments:

<table>
<thead>
<tr>
<th>Cultivars</th>
<th>Fertiliser</th>
<th>Plant density</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Standard</td>
<td>(a) 0</td>
<td>(a) Low: 1 slip/set</td>
</tr>
<tr>
<td>3 Introduced</td>
<td>(b) 100 kg N/ha + 400 kg K/ha</td>
<td>(b) High: 3 slips/set</td>
</tr>
</tbody>
</table>

For low plant density treatments, two standard cultivars and one introduced cultivar are alternately planted into 15 sets on each mound. For high density treatments each set contains two standard cultivars plus one introduced cultivar.

The problem of early and late harvest is overcome by harvesting two sets of each cultivar at the low density and seven sets per mound at the high density, at the early harvest date. The remainder of the mound is harvested at the later date. This design does not allow for a statistical comparison between early and late harvests, but will provide information on individual cultivar bulking rates.
doubling of treatments would provide sufficient data for a statistical comparison between early and late harvest data.

**POLYCRoss BREEDING POTENTIAL IN PAPUA NEW GUINEA**

In this paper I have presented only a limited description of selected cultivars in the Southern Highlands Province. This work demonstrates the vast variation between cultivars on any individual phenotypic or performance trait. Evaluation by Li (1982) of some Papua New Guinea selections showed a wide range of values for yield, nutritional content, and adaptability to varying environments. This diverse genetic base will provide an invaluable resource, provided selected desirable plant characters can be incorporated into new breeding lines.

Martin (1982) summarised the previous ten years advances in sweet potato breeding. His conclusion was that "open pollinated populations and mass recurrent selection, followed by careful screening for new cultivars, are probably the best techniques that the plant breeder can employ". This approach requires the establishment of stringent screening guidelines and a knowledge of the hereditary relationships of the screening criteria. Jones et al. (1979) estimated the heritability for his WDS complex of soil insects to be 0.37 ± 0.11. In the five year period from 1970 to 1975, the percentage of lines with WDS resistance increased from 45-50 per cent to 70-75 per cent. Jones et al. (1980) described the development of cultivars with multiple disease, nematode, and insect resistance. In all areas, significant progress is being made in incorporating multiple characters into newly developed lines.

Studies on the heritability of protein content, trypsin inhibitor activity, and amino acid levels have only recently been completed. Li (1982) reported a heritability of 57 per cent for crude protein using variance/covariance techniques. The predicted advance was 6.9 per cent of the mean by mass selection of the best 10 per cent. Li (1974) also reported a small positive partial correlation of 0.07 between protein content and root yield. In more recent work by Dickey et al. (1983) a population of 100 seedlings was studied to determine the relationships among protein, non-protein nitrogen, trypsin inhibitor activity (TIA) and amino acids. The mean protein content of the 100 seedlings studied was not significantly different from that of the parents. The correlation coefficient for TIA with percentage protein was (r = 0.15). Valine, aromatic and sulfur-containing amino acid levels decreased in the selected seedlings compared to the parents.

The information we now have on the sweet potato cultivars in the Southern Highlands Province indicates huge variations in all plant characters which have been measured. This variation will no doubt be shown to be much larger when all Papua New Guinea cultivars are studied. Progress with sweet potato breeding on a world-wide basis has been slow, but it is now rapidly advancing using the open pollinated mass recurrent selection breeding system. This system combined with overall low correlations between plant characters has opened the door for a "tailor-made cultivar". Improvement of the sweet potato at the subsistence level in Papua New Guinea can be achieved by exploiting the existing genetic base to the maximum.
REFERENCES


EFFECT OF AN ORGANIC MANURE ON THE YIELD OF Taro

A. M. Gurnah

Department of Agriculture, University of Papua New Guinea, Lae, Morobe Province

ABSTRACT

An experiment was conducted at the University of Papua New Guinea farm near Lae to determine the response of taro Colocasia esculenta (L.) Schott var. esculenta cultivar 'White Bumayong' to goat manure applied as an organic fertiliser. Partly decomposed goat manure was applied to taro at the rates of 0, 10, 20, 30 and 40 tonnes/ha. The taro plants were spaced at 60 cm x 60 cm. The treatments were arranged in a randomised complete block design, replicated four times. The experiment was planted on 2 October 1981 and harvested 6.5 months later. The manure treatments resulted in a linear yield response from 5.5 t/ha corms with no manure application to 25.8 t/ha corms at the highest manure application rate. The regression equation of best fit was: yield of corms (t/ha) = 7.1 + 0.4 x tonnes/ha goat manure. Average corm weights also increased linearly from 153 g to 716 g per plant, and the equation of best fit was: corm wt (g) = 160 + 12.8 x tonnes/ha goat manure. Similarly, the number of suckers per plant increased linearly from 2.25 per plant to 7.64 per plant, and the equation of best fit was: number of suckers per plant = 2.33 + 0.13 x tonnes/ha goat manure. The results confirm farmers' contentions that taro yield is sensitive to soil fertility, and that taro should be grown as the first crop in a crop rotation. It also shows that organic manures can be used where available in place of the long fallow under forest. Further work is required to determine optimum rates of manures to apply, and to investigate the residual effects of organic manures on soil fertility.

INTRODUCTION

Taro (Colocasia esculenta (L.) Schott) is an important staple crop in Papua New Guinea (PNG). Because farmers feel it requires high fertility, they grow it as a first crop after a forest fallow. In some parts of Papua New Guinea, for example the Gazelle Peninsula of New Britain Island, land is becoming scarce, and newly cleared land will become less readily available. Another means of restoring soil fertility will be required in the future. Taro is known to respond to fertilisers (De Gues 1973). Reports of the response of taro to organic manures are lacking.
MATERIALS AND METHODS

The experiment was conducted at the University of Papua New Guinea (UPNG) farm near Lae in Morobe Province. The soil is a gravelly, friable light sandy clay loam. The land was prepared by a single disc ploughing and two disc harrowings.

The manure used was partly decomposed goat droppings. It was applied to the plots after harrowing, and worked into the soil with spades. Taro planting setts about 30 cm long were planted at a depth of approximately 20 cm and a spacing of 60 cm x 60 cm. Each plot contained 7 rows of 10 plants each. The outer plants in each plot were used as guard rows, and only 40 plants were harvested in each plot. The treatments in tonnes per hectare of manure were: 0, 10, 20, 30 and 40.

The treatments were arranged in a randomised complete block design replicated four times. There were no paths between plots in the same block but the blocks were separated by paths 2 m wide. The experiment was planted on 2 October 1981 and harvested on 22 April 1982. Rainfall during the growing period was 2267 mm.

RESULTS AND DISCUSSION

Yield per hectare, mean corm weight and mean sucker number per plant are presented in Table 1. After analysis of variance, the treatment sum of squares was partitioned into linear, quadratic, cubic and quartic components. In each case the linear component was very highly statistically significant (P<0.001) and the other components were non-significant.

<table>
<thead>
<tr>
<th>Component of yield</th>
<th>Goat manure, tonnes per hectare</th>
<th>Std. error&lt;sup&gt;1&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corm yield (t/ha)</td>
<td>0   10   20   30   40</td>
<td>2.69</td>
</tr>
<tr>
<td>Mean corm weight (g)</td>
<td>153  301  402  526  716</td>
<td>73</td>
</tr>
<tr>
<td>Suckers/plant</td>
<td>2.25 4.01 4.53 5.76 7.64</td>
<td>0.81</td>
</tr>
</tbody>
</table>

<sup>1</sup>Standard error of the difference between two means.
Yields increased linearly from 5.51 t/ha to 25.77 t/ha with increasing rate of goat manure application. The regression equation of best fit was:

\[
\text{yield of corms (t/ha)} = 7.1 + 0.4 \times \text{t/ha goat manure applied.}
\]

The very substantial increase in yield with increasing fertility was expected since the soil on the UPNG farm near Lae contains very low levels of plant nutrients, and taro is known to respond to soil fertilisation. Other crops have shown similar responses to fertilisers on this soil (A. M. Gurnah, unpublished data). A number of workers have obtained large responses to fertilisers by taro in different parts of the world (Hodnett 1958; De La Pena and Plucknett 1967; Sharma et al. 1969). However, no reports of taro response to organic manures are known to the author.

Since the taro cultivar used in this study produces only one corm, increases in yield came about through increases in corm weight. The regression equation of best fit was:

\[
\text{mean corm weight (g)} = 160 + 12.8 \times \text{t/ha goat manure applied.}
\]

Increases in soil fertility resulted in larger plant size and, for this cultivar, corm weight is generally a constant proportion of total plant weight. The number of suckers also increased with increasing fertility. The cultivar used is a prolific producer of suckers, and under good growing conditions more suckers are produced.

The results of this experiment indicate that manures can be used to maintain or even increase yields of taro in old gardens.

**CONCLUSIONS**

The positive response obtained with goat manure gives a good indication that organic manures can be used to replace the long forest fallow as a provider of adequate fertility for taro, but further work is required to confirm this, and also to determine optimum levels of manures to be used, and their residual effects.

**REFERENCES**


DIFFERENT POPULATIONS OF FOUR INSECT PESTS FOUND ON SIXTEEN CULTIVARS OF AIBIKA (MÁLVACEAE) ABELMOSCHUS MANIHOT

J. B. Sutherland

Senior Entomologist, Bubia Agricultural Research Centre, P.O. Box 73, Lae, Morobe Province

ABSTRACT

Aibika (Abelmoschus manihot (Linn.)) is a nutritious crop which is susceptible to insect attack, especially when planted as a monocrop, or in nearly pure stands which are most suited to institutional gardens. Damage can sometimes be so severe that the plant is totally destroyed. Population levels of four major insect pests of aibika were monitored on sixteen cultivars arranged in a balanced lattice trial. Differences in the numbers of insects found on the cultivars were statistically significant, but no single cultivar had consistently fewer of all four species feeding on it. Results showed that the selection of cultivars with lower levels of susceptibility to insect attack could be part of an integrated approach to pest control.

INTRODUCTION

Aibika is a nutritious leafy green vegetable (Hamilton 1955) grown as a perennial bush in many parts of Papua New Guinea (PNG) up to an altitude of approximately 1600 m (Bourke 1981). A wide variety of cultivars are propagated vegetatively from hard and soft wood cuttings. Cultivars differ in leaf shape and colour from broad, smooth and dark green to highly pinnate, crinkly and red. The growth habit is a herbaceous shrub, varying in height but usually 1.5 m to 2.0 m when harvested regularly. Aibika is generally susceptible to insect attack and several species can cause damage (Sutherland 1983).

The object of this trial was to ascertain whether any differences in susceptibility to insect attack existed between sixteen of the cultivars held at Bubia Agricultural Research Centre (BARC) located 15 km north west of Lae, at 6° 40' S, 146° 55' E at an altitude of 30 m above sea level. Annual rainfall at BARC is 3025 mm (McAlpine et al. 1975).
MATERIALS AND METHODS

Insect Pests

Several insect pests have been recorded from aibika (Sutherland, ibid.) but of these only four are regularly a serious problem, and were monitored during this trial. They are described below.

**Empoasca quadripunctata** (Homoptera: Cicadellidae).
A pale green jassid (or leaf hopper) with a small black spot at the tip of each fore-wing. The feeding of both adults and nymphs can cause severe damage. This insect is an important pest but because of its small size (2-3 mm) and its habit of feeding on the lower surfaces of leaves, it is often not appreciated by growers. Early damage is seen as a slight chlorosis (often confused with nutrient deficiency or virus disease) and this gradually becomes more severe until hopper-burn and complete defoliation occurs.

**Nisotra basselae** (Coleoptera: Chrysomelidae), aibika flea beetle.
The adult beetle, which has blue elytra and a reddish brown head and thorax, causes shot hole damage to leaves. Severe outbreaks can result in complete defoliation.

**Sylepta derogata** (Lepidoptera: Pyralidae), the aibika leaf roller.
As the common name suggests, this caterpillar rolls leaf margins and feeds from the protection of the roll. Heavy outbreaks result in complete defoliation leaving a skeleton of branches and a frass-filled web.

**Earias vitella** (Lepidoptera: Noctuidae), the spiny tip borer.
This caterpillar feeds at the growing points of the plant and can cause stunting and wilting, especially in young plants. Its presence can be detected by the accumulation of frass around the growing points.

Aibika Cultivars

The cultivar collection at BARC contains forty one cultivars collected principally from the lowland areas of Papua New Guinea. The following were used in this trial (location and alternative code numbers are shown in brackets):

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Code</th>
<th>Description</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>(Aiyura)</td>
<td>B2</td>
<td>(Aiyura)</td>
<td>B4</td>
<td>(Laloki, No. 3)</td>
</tr>
<tr>
<td>B5</td>
<td>(Laloki, No. 9)</td>
<td>B6</td>
<td>(Laloki, L1)</td>
<td>B9</td>
<td>(Keravat, K3)</td>
</tr>
<tr>
<td>B10</td>
<td>(Keravat, K4)</td>
<td>B11</td>
<td>(Keravat), K5</td>
<td>B13</td>
<td>(Laloki, L3)</td>
</tr>
<tr>
<td>B14</td>
<td>(Laloki, L4)</td>
<td>B16</td>
<td>(Keravat, K13)</td>
<td>B17</td>
<td>(Keravat, K12)</td>
</tr>
<tr>
<td>B20</td>
<td>(Keravat, K8)</td>
<td>B21</td>
<td>(Keravat, K7)</td>
<td>B38</td>
<td>(Laloki, L5)</td>
</tr>
<tr>
<td>B39</td>
<td>(Laloki, L6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Agronomy and Trial Design

The sixteen cultivars were laid out in a balanced lattice design with five replicates. Each plot consisted of a single row with four planting positions 1.0 m apart. Two cuttings 0.4 m long were planted at each position on 17th February 1982. Rows were 1.5 m apart. No fertilisers, pesticides or irrigation were applied to the trial.

Insect Counts

The sampling system for counting insects was based on methods used for cotton (also a member of the Malvaceae), modified to allow all eighty plots to be covered in one day. For jassids and flea beetles the numbers of adults on twenty-five medium sized leaves in each plot were counted. Twenty-five different leaves were used for each species, and leaves were selected at random from the eight plants in each plot. For *S. derogata* and *E. vitella* the total number of larvae were counted at two planting positions in each plot. Thus for each cultivar on each sampling date, 125 leaves for jassid and flea beetle and 10 planting positions for the lepidopteran larvae, were surveyed. A total of nine counts were made for jassid and flea beetle, and six counts were made for the two species of caterpillar. The trial was terminated on 26 August 1982.

RESULTS AND DISCUSSION

The mean numbers of insects on each cultivar, results of an analysis of variance and Duncan's Multiple Range Test are given in Table 1. Statistically highly significant differences (P<0.01) existed between some cultivars.

The general crop growth was good and uniform. Rainfall during the period of the trial was 1703 mm, slightly lower than a seventeen year average of 1870 mm. This did not appear to adversely affect the crop.

An estimate of the relative efficiency of the balanced lattice design used in this trial over a randomised block design showed an increase in precision of 31 per cent, 26 per cent and 15 per cent for *S. derogata*, *N. basselae* and *E. vitella* respectively. There was no increase in precision for the jassid counts. The use of the balanced lattice design was therefore justified.

The coefficients of variation (CVs) for jassid, flea beetle and *E. vitella* counts were acceptable (less than 30 per cent), which indicated that the counting methods were satisfactory. However the CV for *S. derogata* was high (56.8 per cent) and some modifications of the sampling technique for this insect will be required.

The principal pest on aibika in a particular situation and at a given time depends on the location and meteorological conditions (J. E. Sutherland, unpublished data). The results of the insect counts made during this trial show that different cultivars are capable of supporting significantly different numbers of insects.
Table 1. Mean numbers of insects per leaf (jassid and flea beetle) and per plant (leaf roller and tip borer) for 16 aibika cultivars, with cultivars ranked from most to least susceptible.

<table>
<thead>
<tr>
<th>Jassid¹</th>
<th>Flea beetle²</th>
<th>Leaf roller³</th>
<th>Tip borer⁴</th>
</tr>
</thead>
<tbody>
<tr>
<td>cv⁵</td>
<td>Mean</td>
<td>cv</td>
<td>Mean</td>
</tr>
<tr>
<td>B1</td>
<td>1.28</td>
<td>B17</td>
<td>0.56</td>
</tr>
<tr>
<td>B39</td>
<td>1.25</td>
<td>B4</td>
<td>0.54</td>
</tr>
<tr>
<td>B13</td>
<td>1.23</td>
<td>B16</td>
<td>0.48</td>
</tr>
<tr>
<td>B16</td>
<td>1.18</td>
<td>B38</td>
<td>0.48</td>
</tr>
<tr>
<td>B2</td>
<td>1.16</td>
<td>B6</td>
<td>0.47</td>
</tr>
<tr>
<td>B38</td>
<td>1.06</td>
<td>B10</td>
<td>0.46</td>
</tr>
<tr>
<td>B17</td>
<td>1.03</td>
<td>B14</td>
<td>0.45</td>
</tr>
<tr>
<td>B10</td>
<td>1.00</td>
<td>B21</td>
<td>0.45</td>
</tr>
<tr>
<td>B11</td>
<td>0.94</td>
<td>B39</td>
<td>0.44</td>
</tr>
<tr>
<td>B14</td>
<td>0.94</td>
<td>B13</td>
<td>0.43</td>
</tr>
<tr>
<td>B5</td>
<td>0.93</td>
<td>B11</td>
<td>0.41</td>
</tr>
<tr>
<td>B4</td>
<td>0.89</td>
<td>B1</td>
<td>0.40</td>
</tr>
<tr>
<td>B21</td>
<td>0.82</td>
<td>B9</td>
<td>0.37</td>
</tr>
<tr>
<td>B20</td>
<td>0.80</td>
<td>B20</td>
<td>0.37</td>
</tr>
<tr>
<td>B9</td>
<td>0.80</td>
<td>B2</td>
<td>0.29</td>
</tr>
<tr>
<td>B6</td>
<td>0.68</td>
<td>B5</td>
<td>0.27</td>
</tr>
<tr>
<td>CV⁶</td>
<td>20.12</td>
<td></td>
<td>3.0</td>
</tr>
<tr>
<td>F⁷</td>
<td>5.48''</td>
<td></td>
<td>3.04''</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹*Empoasca quadripunctata* (Homoptera: Cicadellidae).
²*Nisotra basselae* (Coleoptera: Chrysomelidae).
³*Sylepta derogata* (Lepidoptera: Pyralidae).
⁴*Earias vitella* (Lepidoptera: Noctuidae).
⁵Cultivar. ⁶Coefficient of variation.
⁷Variance ratio; all values highly significant (*P*<0.01).
No single cultivar showed less palatability or susceptibility (as measured by insect numbers) to all four species of pest. Where the predominant pest is known, cultivars can be selected accordingly, otherwise a mixture would need to be planted to minimise insect damage. From the results of this trial, cultivars B6, B5, B4 and B14 (all from Central Province) could be planted to reduce damage by jassids, flea beetles, leaf rollers and tip borers, respectively.

Levels of damage and other parameters of crop growth were not measured during this trial, nor were the effects of insect numbers on the quantity and quality of yield recorded. These aspects of the plant's response, the screening of further cultivars and the evaluation of selective insecticides are the subjects of current investigations. What this experiment has shown is that the methods of recording insect numbers are adequate, with the exception that it may be necessary to increase the number of S. derogata samples, and that different cultivars of aibika can support statistically different numbers of insects.

REFERENCES


PART IV:

FOOD PRODUCTION
RICE PRODUCTION: PROSPECTS FOR INCREASING FOOD PRODUCTION, EMPLOYMENT AND IMPROVING NUTRITION IN PAPUA NEW GUINEA

E.P. Abarientos and A.S. Flores

Economics Department, University of Papua New Guinea
Port Moresby

ABSTRACT

This paper discusses the potential for an economically viable rice production industry in Papua New Guinea (PNG). The basic material used comes from an earlier paper by the authors (1982). Other relevant information used comes from various projects and feasibility studies conducted in Papua New Guinea by government bodies, private individuals and consulting firms. Results of the study conducted by the authors indicated relatively high yields of rough rice in Papua New Guinea, and possible labour intensive farming practices. Other crops, such as vegetables and other non-perennial crops, can be produced before or after the rice crop, thus increasing the possibility of higher cash income for the farmer and his family. With abundance of family labour, bottlenecks in labour requirements for various farming practices will not be a problem. Included in the overall agricultural development plan, rice production can bring about increased food production, employment, and improved nutrition in the country, as well as substantial savings in foreign exchange due to import replacement.

INTRODUCTION

Rice growing was introduced into Papua New Guinea (PNG) in the late 19th Century. However, the area devoted to rice production has been limited to small scale subsistence farming, and some attempts for large scale mechanised farming in Bereina, Central Province. Rice consumption has expanded rapidly, and annual import estimates in the 1980s have reached about 100,000 tonnes, growing at the rate of about 16 per cent per year. With the current (1983) estimated price of K350 per tonne (this was the cost estimate of the recent Asian rice import), the annual import bill will amount to about K35,000,000. This is not a small amount, considering that the country is presently experiencing balance of payments difficulties.

As the country moves towards more growth and development, the pattern of food consumption may shift from root and tuber crops to cereals, particularly rice. This
possibility threatens to put the country in a precarious situation if nothing is done to investigate the prospect of producing rice locally. The attainment of self reliance and economic independence is not inconsistent with the attainment of self sufficiency in food production for a country such as Papua New Guinea.

The purpose of this paper is to explore the possibility of producing rice domestically, and to see how this can contribute to achieving self sufficiency in food production and to the goals of achieving increased employment and an improvement in the nutrition of the country's population. The latter part of this paper discusses a case study of mechanised rice production in Bereina, Central Province to show that rice could be grown in the country economically. Finally, a discussion on the effects of rice production on employment and improved nutrition nationally will be given.

MECHANISED RICE PRODUCTION

A survey of 41 rice farms in Bereina, Central Province was conducted for the crop year 1978-79. The purposes of the survey were to:

1. determine the actual costs and returns of mechanised rice farming and to ascertain the net benefits derived by the farmers from such ventures;
2. study the existing cultural practices or techniques of production employed, and to evaluate alternative appropriate technologies; and
3. compile information which could be helpful in formulating policies concerning the rice industry and rational resource utilisation.

The more important results of the study which have a bearing on the objectives of this paper relate to the general characteristics of:

1. the farm operators and their families;
2. the farm's utilisation of labour, land and capital; and
3. the costs and returns and other input-output relationships of rice production.

The sample set of farms was divided into four farm size groups, and the above mentioned characteristics were analysed for each of these four groupings.

The Farm Operators and Their Families

The operators of large farms (over 10 ha) were generally younger than their counterparts on small sized (less than 2 ha) farms and those operating middle sized farms (2-5 ha and 5-10 ha). On average, farmer experience in rice growing
was approximately 2 years, with farmers of the large holdings having the longest experience, averaging 5.5 years. The average farming family size was 3.4 persons per household and tended to decrease with farm size category.

FARM RESOURCES UTILISATION

Labour Potential and Utilisation

The average potential labour force per farm family was about 3.34 man-equivalents (ME). It appeared to decrease as farm size category increased. Of the potential labour force, an average of 26 per cent was left idle and not used either for farming or non-farming activities (including non-farm employment activities and schooling of family members). The proportion of idle labour decreased with farm size category.

Land Resources

The average farm size for the 41 farms was 3.9 ha which is small by Papua New Guinea standards. Not all the land suitable for farming was planted to rice and other crops. About 60 per cent of the total farm area for small sized farms was left idle. For the largest sized farms the idle area comprised approximately 58 per cent. Only three of the 41 rice farmers studied owned their farms. The rest were either family or clan owned farms.

Capital Investment

Capital investment includes investment in farm machinery, tools and equipment, and on-farm improvements. Tractors and implements constituted the highest single item of capital investment, about K1,000 per hectare (98 per cent of total investment).

COSTS AND RETURNS

Total cash and non-cash operating costs amounted to an average of K200 per hectare or K87 per tonne. Operating costs (cash and non-cash) varied inversely with farm size. A large proportion of the cash costs were in land preparation and planting. It was surprising to find that weeding and pest control were non-cash cost items in rice production.

Rice was not the major crop as far as farm incomes were concerned. It constituted only about 13 per cent of total farm income, was used mainly for cash sales, and averaged about K1,200 per farm or about K310 per hectare.
Some general observations regarding the study follow.

1. The rice yield from the case study farms was relatively high for rain-fed production, averaging 2.2 tonnes/ha. Potential for increased yield exists especially for large mechanised rice farming.

2. The labour requirement for growing rice may not pose a problem, due to the presence of an idle labour force. However, this idle labour force tended to disappear as farm size increased.

3. The intensity of land use for rice production is very low, due to the absence of gravity irrigation. If water is made available, land use intensity may increase, and two crops of rice per year might be a possibility.

4. Cost efficiency exists for larger sized rice farm operations.

5. Rice is a possible cash crop for village farmers in some potential rice growing areas in the country, particularly for larger sized rice farms.

6. There are some indications of younger people being interested in relatively new larger scale ventures as shown in the case of rice production. This typifies a changing attitude towards material desires and family size, a demographic theory postulated by the economist A.T. Lewis.

EMPLOYMENT AND IMPROVED NUTRITION EFFECTS

Unemployment and malnutrition are growing problems in Papua New Guinea society even in the presence of increasing real gross domestic product (GDP) and relatively high per capita income.

Employment Effect

The World Bank forecast for easing the unemployment problem was either bleak or pessimistic until the end of this decade. With about 20 per cent of the labour force being the maximum that can be absorbed in non-agriculture sector employment, the agriculture sector must be ready to absorb the balance of the additional labour force. This is an enormous task that agriculture has to accomplish, and it seems to be impossible.

In his discussion paper, *Policy Guidelines For Agriculture*, the Honourable Minister for Primary Industry, Mr. Dennis Young, pointed out that agriculture holds the greatest potential for creation of productive employment. In a modest way, this is true. Though in Mr. Young's paper it is not through rice production that this challenge can even be partly met. Can it be otherwise?

Although the rice production scheme envisioned for Papua New Guinea is a large scale mechanised irrigated venture, its labour absorption potential is still great if the type of mechanisation introduced is the small 2-wheeled hand tractor type.
instead of the large 4-wheeled tractor being used in Australia and the United States of America. In the Bereina study, the total labour input per hectare per crop averaged about 40 man-days for all farms, though it was higher on small farms than on large farms.

One of the main problems associated with the introduction of rice production is the cost of farm establishment. However, the cost is not insurmountable. Farm establishment can be undertaken in a way such that required areas are opened up as more information becomes available that warrants an expansion of the area under cultivation. One preliminary estimate put the cost of establishing a 2000 ha rice project at about K20 million, or K10,000 per hectare (IBRD 1981). This cost factor is quite unacceptable, and it is unwarranted to put such a large investment into rice production under the present cost-price relationships. However, as food problems become more acute in the years to come, this relationship may change, thus favouring an approach of slowly developing the capacity of the country to meet its growing food staple needs through rice production.

The other possibility, if this cost of establishment cannot be met, is to develop a farming system under dry land conditions where rice is one of the crops that could be grown. The International Rice Research Institute located at Los Banos in the Philippines has developed rice varieties which can be grown under these conditions with high yield and early maturity (100 to 120 days). The establishment of this type of farming system in the country may be less expensive and it warrants further investigation.

The current strategy to depend on root crops to meet the future needs of the country for food could be a move in the wrong direction in the long run. It is unrealistic to expect that as the country develops it will consume more root crops per capita as its staple food. This is due to the fact that income elasticity for root crops is not only negative but also less than that of cereals such as rice. Hence, as income increases, people will tend to buy more rice than root crops. That is why the projection for rice consumption is relatively greater than the projected growth rate of the population. If rice is not the cereal to meet the increasing demand for foodstuffs, which cereal would be more suitable? Certainly it cannot be wheat. Perhaps maize could meet the need, but the present experience and trends appear to favour rice.

**Nutrition Effect**

The change towards more cereal consumption as the country develops could have a desirable effect on nutrition. In the IBRD (1981) report, it was observed that root crops have a low nutrient density relative to cereals, and this is believed to be a factor contributing to malnutrition, especially in children.

In addition, if the type of farming system that is found to be economically viable under Papua New Guinea conditions is that of dry land rice cultivation, double cropping with other crops like fruits and vegetables may be possible. This could result in increased production of other food crops which have high nutritive values.
Production of maize and sorghum together with rice is another possibility. If price relationships favour feedstuff production, then this opens new avenues for integration of livestock and feedstuff production in a country with great potential for meeting its food requirements in staple food, fruit, vegetables, and livestock as well as fish and marine food products.

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THE PAPUA NEW GUINEA AVOCADO INDUSTRY

A.F. Rogers

Horticulturist, Department of Primary Industry, Laloki, Central Province

ABSTRACT

Trends in world, Australian and local production of avocados are compared. The root rot fungus *Phytophthora cinamomi* has affected some groves of trees in Papua New Guinea (PNG). Site selection is extremely important to help combat this disease. Quarantine restrictions now prohibit the export of non-virus indexed local avocados to Australia. Australian State regulations also restrict the export of local fruit. Importation of clonal virus indexed propagating material from Australia commenced in 1981. The use of this is compared with local selections for both the local and export market. The propagation of these improved varieties is discussed. Fruit picking and packaging methods in Papua New Guinea have caused high losses, and ways to improve this are discussed.

INTRODUCTION

The avocado (*Persea americana*), a member of the laurel family, is an upright tree that usually grows to a height of 5-10 m with a canopy diameter up to 10 m.

There are three races of avocados; they originate from Guatemala, Mexico and the West Indies respectively, and each has distinctive features. However cross pollination permits the development of hybrids and new cultivars.

As far as can be ascertained, the first avocado trees to become established in Papua New Guinea (PNG) were introduced by the Germans. Initially, most trees were grown in the Rabaul area, but scattered plantings are now widespread throughout the country. Many of these trees appear to be of West Indian origin.

The avocado is one of the most nutritious fruits known, having a high content of polyunsaturated oil, and useful amounts of protein and vitamins. In the countries of origin, the avocado forms a major part of the diet of the native people. Papua New Guineans refer to the fruit as "butter" because the pulp is spread on bread and biscuits.
AREAS OF WORLD PRODUCTION

World production of avocados is estimated at 1.4 million tonnes per annum (Food and Agriculture Organisation of the United Nations 1980). The main producing countries are Mexico (33 per cent of world production), Dominican Republic (14 per cent), Brazil (9 per cent), United States of America (7 per cent), Peru (5 per cent) and Indonesia (4 per cent). Other countries producing avocados commercially include Cuba, Argentina, Israel, Hawaii, Australia, New Zealand and some islands of the South Pacific. Much of the fruit produced in these countries is consumed locally but a world export trade is expanding.

AUSTRALIAN PRODUCTION

Production of avocados in Australia has grown rapidly over the last few years as more trees have matured and plant diseases have been better controlled. Production increased from 662 tonnes in 1978 to 1729 tonnes in 1981 (Anonymous 1982).

The ratio of non-bearing trees to the total number of trees is currently high throughout Australia, which indicates that there will be a rapid increase in production over the next few seasons. In 1978 non-bearing trees numbered 85,000 compared with 33,000 bearing trees. By 1981 non-bearing trees had increased to 148,000 and bearing trees to 91,000.

About 60 per cent of the avocado crop originates from South Eastern Queensland, with the North Coast of New South Wales supplying most of the balance. However, production is increasing in all other States except Tasmania, and particularly in the lower Murray Valley and in Western Australia.

PAPUA NEW GUINEA PRODUCTION

The Rabaul area originally produced nearly all the avocado crop in Papua New Guinea, and most of the trees throughout the country have originated from there. Over 30,000 seeds were distributed from Keravat to the highlands prior to 1968. Most of the fruit from the Rabaul area appears to be consumed locally, as the cost of air freight prohibits transport to the Lae and Port Moresby wholesale markets. Fruit currently (as at 1983) sell for 10 toea each in the Rabaul market.

Central Food Marketing (CFM) in Port Moresby purchased approximately five tonnes of avocado fruit in the year ending August 1980, and approximately 3.7 tonnes in the subsequent year. In both years, production of fruit peaked from November through to June. In the year May 1982 to May 1983, CFM purchased approximately one tonne of fruit.

The wholesalers Niugini Produce Pty. Ltd. in Lae now market approximately 100 kg per month of avocados to CFM, and a similar quantity is sold within Lae. Small amounts are also sold to other centres such as Popondetta, Kimbe and
Madang. Niugini Produce purchase fruit within Morobe Province, the main production coming from the Wau and Bulolo areas, and they are always oversupplied.

With the recent introduction of weekly vegetable flights from the highlands to Port Moresby, Steamships Pty. Ltd. now purchase 100-150 kg of avocados weekly. Both CFM and Steamships Pty. Ltd. land fruit for approximately 85 toea per kilogram, and fruit retails for K1.75 per kilogram. Burns Philp Pty. Ltd. in Port Moresby do not buy any air freighted avocados but occasionally make small local purchases.

ENVIRONMENTAL REQUIREMENTS

Avocado trees will grow over a wide altitudinal range but will not tolerate frosts. Temperature is the major factor modifying flower behaviour. Two common cultivars in Australia, ‘Hass’ and ‘Fuerte’, are adversely affected by both high and low temperature.

Avocados are suited to most soil types but shallow hardpan and clay soils are unsuitable. Such soils are difficult to drain and favour the development of the soil fungus Phytophthora cinamomi, to which avocados are extremely susceptible. Light to medium textured soils with a rooting depth of at least one metre are best. The pumice soils of the Rabaul area are ideal because of their free draining nature.

Whilst avocados will not tolerate waterlogged soils, they should also never suffer from water stress. Trees must receive regular rainfall throughout the year. Much of the lowland Central Province is unsuitable for avocado culture unless irrigation can be applied.

EXPORT OF AVOCADOES

In the mid-1970s, the Food Marketing Corporation endeavoured to export avocados to Australia but encountered difficulties from the Australian importers regarding fruit size, quality and packaging.

In 1977, Australia and New Zealand placed import bans on avocado fruits and seeds from Papua New Guinea due to an inability to satisfy quarantine requirements to certify that the fruit were free from sunblotch virus. Japan also banned imports of Papua New Guinea avocados for the same reason.

Australian Quarantine Regulations

Quarantine regulations require that avocados may only be imported from groves indexed by a recognised authority as being free from sunblotch virus. Indexing of foliar samples involves a complex biochemical test. The Department of Primary Industries in Indorropilly, Brisbane will index samples at a cost of $50.00 per tree.
No facilities exist in Papua New Guinea to index avocadoes. Field identification of sunblotch virus is made difficult because of the presence of symptomless carriers.

At present the only groves acceptable to the Australian authorities are located in Norfolk Island and New Zealand. Fruit from New Zealand is exported over the Christmas period of about 6-8 weeks when there is virtually no domestic production of marketable fruit, and prices are high. Fruit are normally subject to a ten per cent sample inspection before the consignment is released from the quarantine area to the wholesale market. There it is then subject to inspection under State regulations.

State Fruit Marketing Regulations

The various States of Australia have their own regulations which govern the marketing of fruit. Most have minimum maturity or ripeness regulations for avocadoes. Testing is carried out based on a minimum requirement of 21 per cent dry matter content, and fruit which fails is normally rejected. Bruised and blemished fruit, and fruit which shows contamination by fruit fly or other pests is also destroyed. Maturity regulations in the United States of America and Israel are based on oil content tests.

In addition, regulations require avocadoes to be packed to predetermined patterns of one layer only. Packs may contain from 14 to 37 fruit depending on size.

**IMPORTED AVOCADO CLONES**

In October 1981, fourteen virus indexed avocado clones were introduced from Australia to be used as multiplication stock, and for long-term observation. Ten plants remain and are planted in a grove at the Department of Primary Industry (DPI) Plant Quarantine and Horticultural Station at Laloki. To date the four ungrafted seedlings are performing well, and two have already produced flowers. Seed collected from these four plants will be used as rootstocks. The grafted clones have so far shown disappointing growth. They include some of the more common cultivars grown in Australia such as ‘Fuerte’, ‘Sharwil’ and the rootstock variety ‘Topa Topa’.

A further 150 plants have been ordered from Australia for multiplication stock and these will be planted at the Keravat, Aiyura and Laloki research stations. Australian varieties possibly better suited to the lowland tropics include ‘Rincon’, ‘Ryan’, ‘Hazzard’, ‘Nabul’, and ‘Carlon’ but these cultivars are not yet available from registered nurseries.

If these clones prove satisfactory under Papua New Guinea conditions they should form the basis of commercial production for both the local and export markets. Australian quarantine regulations require that indexed trees be kept separate from non-indexed trees by a distance of at least 15 metres.
Propagation of Avocado Clones

The selection of improved cultivars has led to the use of grafting, mainly whip and tongue, cleft, and patch techniques. Rootstock seedling variability can have a considerable influence on the behaviour of the scion. The search for a method of asexual propagation of rootstocks has had some success, particularly with Phytophthora tolerant clones. However it involves a complicated and expensive procedure not suitable for large scale propagation. Air layers have also produced variable results and are not suitable for mass production.

In lowland areas of Papua New Guinea, grafting may have to be performed in the cooler months or perhaps in air-conditioned rooms. The best results are obtained when grafting is carried out at a temperature below 25° Celsius.

Three seedling trees at the Lowlands Agricultural Experiment Station (LAES) at Keravat have been selected and indexed in Brisbane. Seed from these trees can also be used as rootstocks for the introduced clones.

PAPUA NEW GUINEA SELECTIONS

Some selection work on avocado seedling trees at LAES Keravat was initiated in 1964. In 1974, a table was produced which recorded fruit characteristics for 21 trees. All trees, except three, rated low on a taste scale, having a watery texture, and many carried large seeds within the fruit. Seed from these selections have been distributed for propagating throughout Papua New Guinea.

Much of the fruit marketed in Papua New Guinea contains poor quality flesh, being bland and watery, in comparison with the dry nutty flavour of Australian fruit. Some analytical work was carried out in the DPI chemistry laboratory (1967/68) on samples of avocados from LAES Keravat and from a grower in Goroka. The Keravat samples registered a higher moisture content (75-87 per cent) than those from the highlands (71-74 per cent). Oil content of the LAES Keravat samples ranged from 9.4 to 19.0 per cent compared with the highlands samples of 17.2-19.2 per cent. Preferred world cultivars yield between 26 per cent and 30 per cent oil.

Avocado trees in Papua New Guinea have always been propagated by seed, and the time to bearing is 4-5 years. Grafted cultivars in Queensland bear fruit at 18 months to 2 years of age.

PAPUA NEW GUINEA FRUIT FOR THE LOCAL MARKET

Although there is a wide diversity of avocado fruit within the country, the marketing of this fruit should be encouraged to improve local nutrition. High freight costs to Port Moresby from Lae and the Highlands Region largely restricts the sale of avocados to restaurants and expatriate consumers. Avocados are seldom seen in the Port Moresby markets. The wide disparity in prices between
the Rabaul market (10 toea per fruit) and the Port Moresby supermarkets (K1.75 per kilogram) indicates an urgent need for plantings of avocados to be situated close to the Port Moresby market. The Goilala, Mt. Koiari and Cape Rodney areas would be well suited for avocado cultivation.

The main problem at present relates to picking, grading, and packaging of fruit. Fruit is frequently sent to the Port Moresby wholesalers in sacks containing avocados of varying size, maturity and quality. Central Food Marketing registered a 20 per cent loss of fruit in 1980, and this wastage rate is undoubtedly higher by the time the fruit reaches the consumer.

Harvesting and Packaging

Avocados mature on the tree but do not ripen until they are picked. Although fruit are hard to the touch they are a perishable crop and will be fully ripe in 5-6 days after picking, if stored at ambient temperature. If fruit is to be stored for longer periods, it can be held at ambient temperature for 2-3 days and then cool stored at 16-18°C Celsius.

Mature fruit have the following characteristics:

1. they are generally larger than immature fruit;
2. the skin is dull and lusterless with a powdery appearance rather than shiny;
3. the fruit stalk is large and swollen with a distinct yellowish colour rather than green;
4. the seed coat on opening the fruit is dark, dry and shrivelled rather than pale or whitish; and
5. dark skinned varieties will start to change colour from green to purple.

Harvesting should extend over a 4-6 week period with the most mature fruit picked first. Fruit must be hand picked with secateurs, leaving a short portion of the corky stem. This prevents infection by moulds during ripening.

Stout, shallow cardboard trays are ideal for packing avocado fruit. Deep boxes or sacks encourage bruising which develops during ripening.

CONCLUSIONS

Entry into the Australian market with the existing avocado fruit grown in Papua New Guinea is likely to be extremely difficult. Indexing the many and scattered avocado groves in Papua New Guinea would prove a costly task. Also finding sufficient quantities of a single, pear-shaped, uniform cultivar with a minimum 21
per cent dry matter would probably be impossible. Present Australian planting rates indicate that the Australian market may reach saturation in the near future which will cause prices for avocados to drop.

As avocado fruit becomes more popular in Papua New Guinea, the consumer will increasingly demand a better quality product. To satisfy this, cultivars must be limited as soon possible. Introduced clones should form the basis of future production by growers. Indexed plants must be kept separate from non-indexed plants by a distance of at least 15 m. Introduced clones presently available in Australia may be better suited to the medium altitude areas (1000-2000 metres above sea level). Extension staff must give urgent attention to improved methods of picking and packaging of fruit for the internal market.

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SOCIAL CONSTRAINTS TO THE SUBSISTENCE PRODUCTION OF SAGO

Patricia K. Townsend

Institute of Applied Social and Economic Research, P O Box 5854, Boroko, Papua New Guinea

ABSTRACT

The research reported here is part of a long-term ethnographic study of the people living along the Wogamus River, Ambunti District, East Sepik Province. Our earlier work on sago concentrated on the technology of sago production (1969, 1974) and on nutrition (1973, 1982). In our most recent field session we mapped the sago holdings of Yabatauwe Village, surveyed two transects through sago forest, recorded women’s work activities and interviewed informally about sago. In this paper we discuss those aspects of ownership, labour and exchange which bear on food production.

The ownership of sago stands, while based in patrilineal inheritance, was found to be complicated. Although people claim to have abundant sago, the actual resources of productive palms are limited to a narrow band of better-drained land along the margins of swamp forest. Some management of the largely self-renewing stands is practised.

Women form sago work groups of shifting composition. Sickness is a major constraint to the availability of labour. Women are involved in economic transactions ranging from sharing between households to the sale of sago. These have increased in the last fifteen years, although the area is barely on the fringe of the cash economy. Women are increasingly participating in bride price payments by purchasing cowries and contributing them to the bride price for a kinsman.

Although no mechanised milling of sago has been proposed for this remote area, these findings may have implications for decisions elsewhere about whether to establish sago plantations or purchase ‘surplus’ logs. We found our first impressions of the amount of sago and patterns of ownership had to be substantially revised after more careful research. Mechanisation which might be intended to reduce the drudgery of women’s work would in fact lead to a decline in women’s status, unless other economic activities for women were introduced.
INTRODUCTION

This topic has been chosen for two not entirely compatible purposes. Firstly, I want to draw your attention to sago, a food crop completely neglected at the first two food crops conferences. If the importance of a staple crop is measured by the number of calories per person per day that it provides, sago is third in importance in Papua New Guinea (PNG), following sweet potato and bananas (Harris 1982). Secondly, I want to open up the discussion of the social context within which women produce food. It has been shown that most processes of agricultural intensification in Papua New Guinea place more demands on women's labour than on men's labour (Modjeska 1982). If we are to consider ways in which food production can be increased, we must think about constraints on women's work activities. This paper deals with a Sepik society in which women are doing most of the sago work, and it will consider the factors of resources, labour and demand which determine how much food they produce.

The research reported here is part of a long-term ethnographic study of the people living along the Wogamus river, in Ambunti District, East Sepik Province. Earlier work on sago concentrated on the technology of sago production (Townsend 1969, 1974) and on nutrition (Townsend et al. 1973; Townsend 1982). In our most recent field session we mapped the sago holdings of Yabatauwe village, surveyed two transects through a sago forest, recorded women's work activities, and conducted informal interviews relating to sago.

RESOURCES

One factor which limits the amount of sago starch produced is the number of mature palms available for starch production. The Saniyo-Hiyewe people are using sago which is self-propagating. In their terms it was always there; no one planted it. They know that sago can be planted, but very few men have planted any. One exceptional man has created a small botanical garden by damming up a small stream just below his house and planting one or two specimen suckers of six of the fourteen varieties of sago (naw) named in the local dialect. Since none of these varieties are known to set seed, I suggest that these now infrequent events of planting preferred varieties of sago near a house are the means by which these varieties became established in the area generations or centuries ago.

The productive varieties of sago are concentrated along the margins of the swamp forest, in a band less than 100 m wide along the base of the hills. The swamp forest itself is dominated by 'yapay' (wail saksak), a sago variety which is not considered to be a variety of naw. 'Yapay' suckers strongly and seldom forms a trunk. It yields poorly. (The one 'yapay' plant that we have studied yielded only 17 kg of wet starch.) It is rarely worked, but more frequently used for growing sago grubs (asaye).

To some extent the difference between these wild stands of 'grub sago' and the productive stands is one of management. The Saniyo-Hiyewe recognise that
opening up the stands improves productivity, and they occasionally cut forest trees to increase sunlight.

On most trips to the swamp, people cut a young palm without a trunk for its heart or growing tip. This is eaten raw as a snack. This practice helps to remove excess suckers and thereby thins the stand. Most of the small amount of management of the stands is done by men, but all other sago work is done by women.

Although the Saniyo-Hiyewe emphasise that they have abundant sago, in fact people are now sometimes short of mature sago that is conveniently located. This leads them occasionally to cut trunks which give poor yields (both 'grub sago' and immature palms). (In 1966-67, during my visits I never heard people complain of a sago shortage.) The situation results from settling down into relatively permanent villages, instead of the smaller, less permanent hamlets formed previously. In the case of Mapisi village, which is the site of a new airstrip, trade store, mission preschool and future aid post, this is most noticeable. However it is also true for Yabatauwe and Wourei villages, where people have stayed because "the kiap told them to" and because that is where their names are written down. Whereas in other places, patterns of land tenure and sago ownership may prevent some people from having access to sago, in these villages the ownership patterns seem to result in reasonably good access to sago.

Although land and grub sago are lineage owned, productive sago is individually owned, or shared between a set of brothers and sisters. People claim sago through both parents. Since their parents, in turn, claimed sago through both parents, there is potential for multiple and overlapping claims. This is alleviated by the custom that your parents should have shown you your sago. That is, to own a stand of sago one must keep up the use and management of it, even though there is no tradition of one's ancestors having planted the sago. By moving around to live with different kin in different hamlets, people keep up these multiple claims to sago stands in various places. Thus it could be concluded that semi-nomadism is a social, rather than environmental, necessity.

Labor

In some Melanesian societies women work sago alone, in others sago work is organised communally and the product is divided among the participants. The Saniyo-Hiyewe fall into neither of these categories. Women do not work alone, though sometimes they may just be accompanied by their husbands who do other tasks such as gathering building materials and other foods. Men do not normally work sago, though many will admit to having helped out when there was sickness or when no one else was available. Rather than working communally, women simply work side by side for companionship, using separate washing troughs, thus keeping their product separate.

The daily work activities of all 19 adult women (age 15 and over) resident in Yabatauwe village were recorded for 35 days, from 20 December 1982 to 23 January 1983. During this time women worked sago an average of 18 hours per week. Since sago is the staple food providing 85 per cent of their food energy, this
work can meaningfully be compared with the subsistence farming activities which produce the main staple for women in other societies. For example, Raiapu Enga women expend 22 hours per week on sweet potato gardens (Waddell 1968), Sinasina (Simbu) women spend 20 hours per week in sweet potato gardens (Hide 1981), and Orokaiva women of Inonda Village (Oro Province) spend 15 hours per week in mixed gardening (Waddell and Krinks 1968). However, there are some important differences between gardening and sago making. Firstly, gardening requires heavier initial inputs in clearing and fencing than sago, as managed in the present study area. Secondly, after it is processed, sago is easy to cook as puddings or pancakes without the time-consuming peeling required for root crops.

The sago work partnerships are important social ties. They are constantly forming and reforming around different kinship relationships. Reflecting the patrilineal bias of the community, links through husbands were slightly more common (such as mother-in-law/son’s wife, or the wives of two lineage brothers) than direct links between the women (mother/daughter, sisters, cousins).

For example one woman, Mo’une, worked several short nau tare logs during the five week study period. Thus she had considerable opportunity to change partners. At first she worked alone on her husband’s palms while he built a bush house nearby. After that she worked on his lineage mate Mark’s sago along with Mark’s mother, then on a large nau tavariyo with both Mark’s wife and mother. Next she went in a totally different direction from the village with her own second cousin and lineage mate Tapay to work on sago that was not in fact inherited in that lineage but from Tapay’s mother. As can be seen, the possible complexities are great. Other women continued to work with the same partner for the five weeks, but all changed at least once.

The fact that women coordinate their work is bound to have some effect on production, but whether the net effect is positive or negative is difficult to determine. The companionship encourages them to keep working, but there are times when they do not go to the swamp because of a partner’s change of plans. Also, the total observance of Sunday as a day of rest has been adopted in the last few years; clearly the pattern of coordinating work played a part in this.

In other sago-working societies, the organisation of labour is often a major constraint to production. Where traditionally large communal parties must be organised, or where each household must put together a male/female team, sago production has been drastically affected by the out-migration of males in other Sepik and Gulf Province communities.

Although the organisation of labour is not a constraint to production in the study community, poor health is a significant constraint. Scraping and pounding sago pitch is a very arduous subsistence task. The women observed in this activity study lost at least four per cent of sago work time directly through illness (malaria; injury from a fall; or a child’s respiratory illness). Women with infants worked less than married women with older children, because they had to care for their children and protect them from illness. (Since the infant death rate in the study area is 400 per 1000, this concern is understandable.) Other studies have shown that productivity lost due to illness is greater in the lowlands than in
highlands agriculture, but there have not yet been formal studies of the cost of malaria to productivity in Papua New Guinea. Such a study would need to take into account reduced work output due to anaemia as well as days lost due to acute illness.

In addition to direct loss of work time to illness, subsistence production is reduced indirectly through mourning taboos. Saniyo widows are prohibited from working sago whilst mourning. One of the nineteen women in this study, a thirty year old mother of two young children, worked no sago at all because she was still under most severe mourning taboos, two years after her husband's death. Once the taboos are lifted, older widows work hard.

Another woman in the sample avoided working sago of the common variety. This was because it brought back painful memories of her daughter who died suddenly of (probable) cerebral malaria several years earlier while they had been working that kind of sago together. Thus both directly and indirectly, through cultural means, illness affects food production.

Demand

The most important constraints to sago production in this area relate to demand. Sago provides 85 per cent of the food energy for the community. Pigs and hunting dogs are also fed some sago, but only the smallest pigs are fed significant quantities. In any case the ratio of pigs to people is very low, only 1:8 in Yabatauwé during this study. Much sago enters into inter-household transfers within the community, to provide for the families of widows, widowers, orphans, visitors, and other people temporarily short of food.

The Saniyo, while not showing clinical signs of malnutrition, are short and thin, even by Papua New Guinea standards, and frequently complain of being hungry. Why do they not produce and consume more sago? The answer must be sought in the rest of the subsistence economy, because they say they are not interested in eating more sago unless they have meat, fish or at least greens to eat with it.

There are also very few opportunities for selling sago, but the few which exist are important as a source of wealth and prestige for women. The mission has bought some sago for its schools at Mapisi and Ambunti. At a bride price ceremony held during the study period, four of sixteen contributors were women giving beads and shell valuables, purchased with cash or sago, on behalf of their kinsman. Other women among the bride's relatives received bride wealth which they will be able to use in later exchanges.

These sales and exchanges are small, however, and the Saniyo-Hiyewe do not have the same stimulus to produce a surplus as the Sepik Hills people who exchange sago for fish at Chambri Lakes (Gewertz 1977) or the Sawos women who similarly exchange with the Iatmul (Schindlbeck 1980). The systems of traditional trade based on ecological specialisation which emerged in the middle Sepik never developed to the same extent in the upper Sepik, though occasionally sago was (and is) taken to Kubkain or the Sepik for barter. Schindlbeck's (1980) study
showed that Sawos women worked sago to almost exactly the same extent as the Saniyo-Hiyewe (29 per cent of Sawos woman-days compared with 31 per cent of Saniyo-Hiyewe woman-days). Much of this is production for market, and in addition, the Sawos work far more days than the Saniyo-Hiyewe on gardening and fishing. They lose 3.2 per cent of activity time to sickness and menstrual taboos.

In summary, the main constraints to Saniyo-Hiyewe sago production are in the area of demand, for both subsistence and market production. An emerging constraint is the resource base itself, as a result of changing settlement patterns. People have the knowledge needed to increase their sago stands, but the lead time for doing so is very long, in the order of twenty years. Except for a heavy burden of sickness, the availability of labour is not as serious a constraint as in other parts of the country where more out-migration has occurred.

REFERENCES


TRENDS OF FOOD PRODUCTION AND CONSUMPTION IN THE PAST TWENTY YEARS AND POTENTIAL PRODUCTIVITY OF MAJOR CROPS IN PAPUA NEW GUINEA

Y.H. Yang

Project Preparation Team, Center-Wide Programs, East-West Centre, Honolulu, Hawaii, United States of America

ABSTRACT

Based on publications of the Food and Agriculture Organisation (FAO) of the United Nations, aggregated agricultural production in Papua New Guinea (PNG) has increased at a rate slightly higher than the world average in the past 20 years (16 per cent faster overall, and 9 per cent faster for food production). However the relatively low production yields per hectare of major staple crops in Papua New Guinea compared with yields from experimental plots and compared with world averages indicate the considerable scope for improvement. To achieve higher yields on a national basis there is a need for close cooperation and collaboration amongst many Government and Non-government organizations.

AGRICULTURAL PERFORMANCE

Based on publications of the Food and Agriculture Organization (FAO) of the United Nations, aggregated agricultural production in Papua New Guinea (PNG) has increased at a rate slightly higher than the world average in the past 20 years. Taking production during the period 1961-65 as a base of 100, agricultural production in Papua New Guinea has increased to 170 in 1981, while the world average is 154 for the same period, i.e. production in Papua New Guinea has grown 16 per cent faster that the world average, between 1961 and 1981. In this period, food production in Papua New Guinea increased 66 per cent, while the world average was 57 per cent, i.e. 9 per cent higher in Papua New Guinea compared to the world average. The difference can be attributed to the rapid increase in the production of cash crops, especially coffee. In Papua New Guinea, more emphasis has been placed on cash crops for export than on subsistence crops for domestic consumption.

The per capita production indices show an entirely different situation compared to the figures for the country as a whole. During the past 20 years, Papua New Guinea per capita agricultural production increased by 8 per cent, and per capita
food production increased by only 5 per cent. The corresponding figures for world averages are 11 per cent and 13 per cent respectively. In other words, the rapid population growth in Papua New Guinea diluted the production effort during this period. Nevertheless, Papua New Guinea leads all other Pacific Island countries in the speed of increase of both total production and per capita production.

**PER CAPITA FOOD SUPPLIES**

Although the per capita availability of food, as expressed in the food balance sheet, could conceal real problems existing in different population groups, geographic areas, and/or seasons of a country, it is, nevertheless, a practical instrument to use to plan food supply at the national level. The FAO of the United Nations (UN) publishes time series food balance sheets for more than 120 countries. The change in food availabilities in Papua New Guinea for the past 20 years is summarized in Table 1. Again, the rate of increase in per capita food supplies in Papua New Guinea compared very favourably with those of other Pacific Island countries.

| Table 1. | Increase in per capita food supplies (calories and protein) in Papua New Guinea, by years for the period 1961 to 1980. Data are scale figures to illustrate changes with time. |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| **Food component** | **1961-65** | **1966-69** | **1969-71** | **1975-77** | **1978-80** | **Per cent increase** |
| Calorie total     | 2026          | 2107          | 2187          | 2215          | 2286          | + 12.8          |
| comprising:               |               |               |               |               |               |                 |
| Vegetable products      | 1854          | 1913          | 1977          | 2002          | 2052          | + 10.7          |
| Animal products        | 172           | 193           | 215           | 213           | 234           | + 36.0          |
| Protein total          | 40.2          | 42.9          | 45.1          | 43.7          | 46.7          | + 16.2          |
| comprising:               |               |               |               |               |               |                 |
| Vegetable products      | 27.3          | 28.7          | 29.6          | 29.8          | 30.9          | + 13.2          |
| Animal products        | 12.7          | 14.2          | 15.5          | 13.9          | 15.7          | + 23.6          |

Source: FAO Production Year Books.
DEPENDENCY ON FOOD IMPORTS

In the past, because of economic growth in Papua New Guinea, food imports increased year by year, accounting for some 16-20 per cent of the total commodity imports of Papua New Guinea. A summary of energy and protein supplies from domestic and imported sources in Papua New Guinea is shown in Table 2.

POTENTIAL PRODUCTIVITY OF MAJOR FOOD CROPS IN PAPUA NEW GUINEA

We have learned, at this conference and elsewhere, of the great disparity between the yields of major crops at the farm level and those at experimental stations where greater production inputs, including improved cultural practices, are provided. We may also compare the crop productivity of Papua New Guinea with that of the world average, and those of some technically advanced countries such as Australia and the United States of America (USA) (Table 3).

From Table 3, it is evident that the cash crops, namely coffee and sugar cane, performed relatively well in Papua New Guinea, whereas the productivity of food crops for domestic consumption was much lower than the world average and the averages for Australia and the USA. From a positive viewpoint, these discrepancies indicate the potential for improvement in productivity provided the necessary production inputs are used. This would require effort and the cooperation of all concerned.

A coordinated approach is much needed in Papua New Guinea. We are trying our best to define the severity and magnitude of nutrition problems in Papua New Guinea, particularly among the high risk groups. The nutritional requirements of people is determined by their physiological needs, activities, and environment.

The assessment and monitoring of nutritional status of people often falls within the responsibility of the Health Department. The nutritional needs of people can only be fulfilled through food consumption in adequate quantity and suitable quality. Food consumption satisfies nutritional needs and, hopefully, conversely the nutritional needs of people stimulate food consumption.

Food consumption is affected by income, education, culture, food habits, mass media advertising, and government food pricing policy. Hence its influence is within the jurisdiction of economic, education and information departments of government. Food consumption also depends upon food supply which, in most countries, depends upon domestic production, supplemented, if necessary, with imported foods.

For an efficient supply of good quality food, local or imported produce requires post-harvest protection, appropriate food technology inputs, and efficient marketing. This falls within the responsibility of agriculture, science and technology, and finance Departments.
Table 2. Average energy and protein supplies to Papua New Guinea from imported sources, and the ratio between domestic and imported supplies, for the period 1975-77. Data are relative values.

<table>
<thead>
<tr>
<th>Source</th>
<th>Calories</th>
<th>Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>2215</td>
<td>13.9</td>
</tr>
<tr>
<td>Imported food</td>
<td>503</td>
<td>6.4</td>
</tr>
<tr>
<td>Imported/domestic ratio</td>
<td>22.7</td>
<td>46.0</td>
</tr>
</tbody>
</table>

Source: FAO

Table 3. Yield (kg/ha) of major crops in Papua New Guinea, the World, Australia, and the United States of America in 1981.

<table>
<thead>
<tr>
<th>Crop</th>
<th>PNG</th>
<th>World average</th>
<th>Australia</th>
<th>USA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice, paddy</td>
<td>2885</td>
<td>2885</td>
<td>7179</td>
<td>-1</td>
</tr>
<tr>
<td>(Index)</td>
<td>(100)</td>
<td>(100)</td>
<td>(249)</td>
<td>(-)</td>
</tr>
<tr>
<td>Maize</td>
<td>2000</td>
<td>3370</td>
<td>-</td>
<td>6898</td>
</tr>
<tr>
<td>(Index)</td>
<td>(100)</td>
<td>(185)</td>
<td>(-)</td>
<td>(345)</td>
</tr>
<tr>
<td>Sugarcane</td>
<td>61176</td>
<td>56100</td>
<td>-</td>
<td>88802</td>
</tr>
<tr>
<td>(Index)</td>
<td>(100)</td>
<td>(134)</td>
<td>(183)</td>
<td>(-)</td>
</tr>
<tr>
<td>Groundnuts</td>
<td>750</td>
<td>1002</td>
<td>1374</td>
<td>-</td>
</tr>
<tr>
<td>(Index)</td>
<td>(100)</td>
<td>(134)</td>
<td>(183)</td>
<td>(-)</td>
</tr>
<tr>
<td>Starchy roots:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweet potatoes</td>
<td>4545</td>
<td>12384</td>
<td>11818</td>
<td>-</td>
</tr>
<tr>
<td>(Index)</td>
<td>(100)</td>
<td>(272)</td>
<td>(260)</td>
<td>(-)</td>
</tr>
<tr>
<td>Irish potatoes</td>
<td>4167</td>
<td>14387</td>
<td>25842</td>
<td>-</td>
</tr>
<tr>
<td>(Index)</td>
<td>(100)</td>
<td>(345)</td>
<td>(620)</td>
<td>(-)</td>
</tr>
<tr>
<td>Coffee, green</td>
<td>1306</td>
<td>574</td>
<td>-</td>
<td>1178</td>
</tr>
<tr>
<td>(Index)</td>
<td>(100)</td>
<td>(44)</td>
<td>(-)</td>
<td>(90)</td>
</tr>
</tbody>
</table>

1No data available.
Source: 1981 FAO Production Year Book.
Food supply satisfies food consumption, and food consumption (demand) stimulates food supply. It is hoped that one day a country's food supply may be guided by, and satisfy, the nutritional needs of the people of the country. When food supply fails to meet the requirements for adequate food consumption, and/or food consumption fails to meet the nutritional needs of the people, appropriate intervention programmes should be introduced to ensure that the health and welfare of the people is properly protected.

Thus, many Departments and disciplines are involved in the food and nutritional improvement of the people. A well coordinated approach among all concerned can ensure better use of resources, and avoid duplication and conflicts among them, in achieving the planned goal.
### APPENDIX

**AGRICULTURAL AND FOOD PRODUCTION INDICES OF PAPUA NEW GUINEA COMPARED TO THOSE OF THE WORLD AVERAGES BY YEAR, 1961-65 = 100.**

<table>
<thead>
<tr>
<th>Year</th>
<th>TOTAL</th>
<th>PER CAPITA</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Agricultural production</td>
<td>Food production</td>
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<td>Food production</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PNG</td>
<td>World</td>
<td>PNG</td>
<td>World</td>
<td>PNG</td>
<td>World</td>
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<tr>
<td>1962</td>
<td>97</td>
<td>98</td>
<td>97</td>
<td>98</td>
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<td>100</td>
<td>100</td>
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<td>100</td>
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</tr>
<tr>
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<td>102</td>
<td>103</td>
<td>100</td>
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<td>113</td>
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</tr>
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<td>118</td>
<td>116</td>
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<td>105</td>
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<td>1974</td>
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<td>134</td>
<td>109</td>
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<td>170</td>
<td>154</td>
<td>166</td>
<td>157</td>
<td>108</td>
<td>111</td>
</tr>
</tbody>
</table>

LAND EVALUATION FOR FOOD CROP PRODUCTION IN PAPUA NEW GUINEA

David J. Radcliffe

Agricultural Field Trials, Studies, Extension and Monitoring Unit, Southern Highlands Rural Development Project, Mendi, Southern Highlands Province

ABSTRACT

Land evaluation, defined as the assessment of land performance when used for specific purposes, is recommended as an essential technique for planning the changes in land use required to increase production of food crops. The methodology of land evaluation according to the Food and Agriculture Organisation of the United Nations ‘Framework’ is outlined and illustrated with reference to the evaluation of four areas of land on experimental farms in Southern Highlands Province, for sweet potato production using traditional techniques. The results are expressed in terms of ‘land suitability classes’ with expected yield ranges, acting limitations, land management practices and response to inputs. Suggestions are given on the application of this data to making land use decisions.

INTRODUCTION

Correct assessment of land performance under different kinds of productive use is fundamental to designing strategies for increasing food production and for determining whether, in the long term, Papua New Guinea (PNG) can support its expanding population without recourse to costly food imports.

Land evaluation is defined as the assessment of land performance when used for specified purposes (Food and Agriculture Organisation of the United Nations 1976) and may be regarded as a means of data interpretation for the purposes of taking decisions on land use. In the present context where the objective of increased food production in a given area could be met by increasing the area under cultivation or intensifying existing production systems, land evaluation provides a rational basis for analyzing the benefits and limitations of competing strategies and selecting the most acceptable alternative.

Land evaluation is not an end in itself but is a vital part of the rural development decision making process. Figure 1 illustrates how land evaluation links data collection with decision making.
Figure 1. Generalised sequence of activities in rural development planning. [Source: Food and Agriculture Organisation of the United Nations (in press).]
This paper gives an account of the principles and methodology of the Food and Agriculture Organisation of the United Nations ‘Framework for Land Evaluation’ (Food and Agriculture Organisation of the United Nations 1976) and describes how to carry out a land evaluation with reference to a single type of land use practised on four contrasting land types from the Southern Highlands Province. The examples chosen are located on experimental farms, and guidelines are given on using the results of the evaluation to allocate experimentation and extension priorities on these farms. Other important applications of land evaluation which are not considered in this paper include:

(1) determining the economic feasibility of smallholder commercial crop projects;

(2) identifying reasons for production-related malnutrition and evaluating strategies for its amelioration; and

(3) determining how many people a given area of land (e.g. a clan area or a district) can support, and identifying areas of present or future population pressure.

**PRINCIPLES AND LOGIC OF LAND EVALUATION**

Land evaluation is carried out according to the following principles (Food and Agriculture Organisation of the United Nations 1976).

1. Land suitability is assessed and classified with respect to specific kinds of use.

2. Evaluation requires a comparison of the benefits obtained and the inputs needed on different types of land.

3. A multidisciplinary approach is required.

4. Evaluation is made in terms relevant to the physical, economic and social context of the area concerned.

5. Suitability refers to use on a sustained basis.


The FAO land evaluation methodology is essentially ecological in approach. The land use is assumed to be in a state of dynamic equilibrium with the land. Hence the performance of the land use, normally crop yield, is dependent on the properties of the land. Furthermore, the efficiency of any external inputs to the land use (such as fertiliser) or to the land (such as drainage) depends on the interactions between land properties and the particular technology of land use.
By analysing these relationships, land evaluation aims to predict how a particular land utilisation type (LUT) will perform on a particular land unit (LU) and to predict how this rating would change if:

(a) the same LUT was practiced on a different LU;
(b) a different LUT was practiced on the same LU;
(c) physical inputs were added to the system; or
(d) the land was improved (for example by drainage).

The essential technique used by land evaluation is matching the attributes of the land with the requirements of land use under specified input levels. Matching poses the question 'how well do the properties of the land satisfy the requirements of the land use?' The answer is provided in terms as quantitative as the data allow.

By focussing on the specific requirements of particular types of land use, and evaluating land according to how it meets these requirements, the methodology outlined in this paper differs markedly from methods of land assessment that have previously been used in Papua New Guinea, for example by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) (Haantjens 1963, 1969). However the FAO system of land evaluation is now being extensively used in countries as geographically and sociopolitically diverse as Brazil, Ethiopia and New Zealand, and it is interesting to note that CSIRO is now advocating an approach based on similar principles for evaluating land for smallholder crop production in Papua New Guinea (McAlpine et al. 1982; Bleeker et al. 1983).

**CARRYING OUT A LAND EVALUATION**

Figure 2 gives an overview of the activities involved in land evaluation, from the initial statement of objectives to the presentation of the results of the evaluation in the form of reports and maps.

These procedures can be separated into a number of steps as given below.

1. Identify the land utilisation types (LUTs) to be considered in the evaluation.
2. Describe each LUT.
3. List the land use requirements (LURs) for each LUT and determine parameters for their measurement.
4. Define critical limits for each requirement corresponding to highly suitable, moderately suitable and marginally suitable conditions.
5. Define the land mapping units (LMUs) to be evaluated and map their distributions.
6. Select the land parameters corresponding to the LURs listed in ‘3’ above and record their values.

7. Compare the values of the land attributes recorded in ‘6’ with the critical limits of LURs in ‘4’ and allocate a Land Suitability Rating (LSR) with respect to each LUR.

8. Review to optimise LSRs taking account of feasible physical inputs and land improvements.

9. Combine LSRs to give a Land Suitability Class (LSC)

10. Review and field check.


13. Present results in terms of reports, maps, and practical recommendations.

Figure 2. Diagrammatic representation of a land use system. [Based on Dent and Young (1981) and Beek (1978).]
Steps 1 to 4 and 5 and 6 can be regarded as parallel activities referring to data collection and interpretation on land and land use respectively. Land and land use information is integrated in the matching and evaluation steps from 7 onwards.

Four LMUs from Southern Highlands Province (SHP) are now evaluated for a single LUT, following steps 1 to 13 as indicated in Figure 3. This evaluation is used to illustrate the methodology and may differ from the final evaluation carried out by the Agricultural Field Trials, Studies, Extension and Monitoring Unit (AFTSEMU) of the Southern Highlands Rural Development Project (SHRDP) when data collection and analysis is finally completed. Furthermore the suggested use of physical inputs such as fertiliser does not necessarily imply endorsement of such recommendations by AFTSEMU. The thirteen steps are reviewed below, with particular emphasis on the Southern Highlands Province.

**Step 1. Identify LUTs**

Only one LUT is considered, that of sweet potato cultivation using traditional Mendi cultivation techniques.

**Step 2. Describe LUTs**

LUTs must be described in relation to their production, technical specifications of their management and their social setting. The above LUT may be described using a list of headings suggested by the Food and Agriculture Organisation of the United Nations (in press) as given below.

- **Crops grown:** sweet potato.
- **Market orientation:** subsistence with occasional marketing of surplus.
- **Capital:** nil.
- **Labour intensity:** high.
- **Technical knowledge:** good local perception of plants and land; gardens usually tended by women with no formal education. Fairly conservative attitudes but receptive to demonstrated improvements (e.g. more productive cultivars).

- **Power:** all operations carried out by hand.
- **Mechanisation:** nil.
Figure 3. **Steps in carrying out a land evaluation** (see text for details).
Size and configuration of farm: mean size 800-1000 m\(^2\); each family may have 3-5 holdings of this size, normally distributed on contrasting land types.

Land tenure: individual ownership within clan system. Patrilineal inheritance.

Infrastructure requirements: not applicable.

Cropping practices: semi-continuous monocropping with sweet potato; short fallow periods. (Assumed for evaluation purposes.)

Material inputs: nil (assumed for evaluation). In practice small quantities of fresh compost are often incorporated into the mounds (see below).

Cultural practices: soil heaped into mounds of about 1.5-2.0 m diameter and 40-80 cm high. Sweet potato vines planted into sides of mounds. Mixture of cultivars normally planted in one mound. Weeded usually once during establishment phase. Harvested sequentially from approximately six months according to demand.

Livestock: domestic pigs which consume about 50 per cent of sweet potato produced.

Yields and production: data not yet available for village situations. Experimental farm yields discussed later.

Economic information: no cash inputs; approximate price of produce K0.08-K0.15 per kilogram.

**Step 3. List LURs and determine parameters for their assessment**

Crop plants have a number of basic requirements for germination, growth and yield. When crops are managed, the management system also demands certain requirements of the land in terms of workability, accessibility, etc. Furthermore, sustained use of land demands freedom from hazards of environmental degradation.

Food and Agriculture Organisation of the United Nations (in press) give a checklist of land use requirements which may be applicable to rainfed LUTs. This list is exhaustive and many of the requirements are not relevant to the LUT considered in the present example. Those which are considered important for traditional sweet potato cultivation are listed in Table 1.
In common with other crops, sweet potato requires energy for photosynthesis, moisture, oxygen and nutrients for successful growth and development. In addition it requires favourable physical conditions for rooting and for ease of cultivation (these two requirements are treated together) and freedom from hazards due to adverse climatic effects, flooding or severe incidence of pests or diseases. Apart from accessibility, which is not a limiting factor in the LMUs evaluated, the only management requirement considered is that of soil cultivation. The hazard of erosion must be kept at an acceptable level if production is to be maintained on a sustained basis.

Parameters for rating the nine LURs listed in Table 1 have been selected mainly according to data availability, knowledge of the effects on the crop, and the need for simplicity in using the present example to demonstrate the methodology.

The energy requirement depends on incoming radiation and on air temperature. Until recently, radiation data was totally lacking for the Southern Highlands Province, and information on crop response to different radiation levels is difficult to apply. In this example the energy requirement is assessed on the basis of mean annual air temperature only.

In the wet climate of the Southern Highlands, moisture is more usually a problem due to excess rather than due to inadequacy. Nevertheless sweet potato was observed to show significant growth retardation during periods of relative drought (e.g. the latter half of 1982), and a simple evaluation of this requirement can be made by estimating from climatic records the frequency of significant drought. For completeness, the total moisture requirement over the growing season can also be considered, although it is never likely to be limiting under normal climatic conditions in Southern Highlands Province.

Oxygen supply to roots is governed by the moisture status of the soil, which is a product of incident rainfall, topography, and soil permeability and pore size distribution. This requirement may frequently be limiting in the wet environment of Southern Highlands Province, and traditional cultivation practices of mounding and digging baret drains are primarily intended to keep developing tubers out of waterlogged zones. The excess of rainfall over evaporation is suggested as one parameter for measuring this requirement. The other is the large pore volume (LPV) or aeration porosity of the soil. This property refers to the percentage of transmission (50-500 mm pores) (Greenland 1977) in relation to total soil porosity, and reflects both the number of pores in the soil which hold water only under saturated conditions, and soil permeability.

All crops have requirements for nutrients in varying amounts, and it is possible to carry out a very detailed evaluation on the basis of this requirement alone. In this example, assessment is deliberately simplified. Nitrogen is ignored as it is rarely limiting to sweet potato in the relatively high organic matter soils of the highland part of Southern Highlands Province, and assessment is based on phosphate retention, which is a measure of the soil's ability to 'fix' phosphorus in a form not readily available to the plant, and exchangeable potassium, which gives a reasonable reflection of availability (Boyer 1972). Assessment is also made for five trace elements which may be limiting.

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Table 1. Land use requirements: sweet potato cultivation under traditional Mendi cultivation system.

<table>
<thead>
<tr>
<th>Land Use Requirement (LUR)</th>
<th>Measurement parameter</th>
<th>Units</th>
<th>Range of values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>S1</td>
</tr>
<tr>
<td>Energy</td>
<td>Radiation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Temperature (mean annual)</td>
<td>°C</td>
<td>&gt;16.5</td>
</tr>
<tr>
<td>Moisture</td>
<td>Total (for the growing season)</td>
<td>mm</td>
<td>&gt;800</td>
</tr>
<tr>
<td></td>
<td>Drought hazard</td>
<td></td>
<td>&lt;1 in 8 years</td>
</tr>
<tr>
<td>Oxygen supply to roots</td>
<td>Ratio P/Eᵢ¹ for the growing season</td>
<td></td>
<td>1-2</td>
</tr>
<tr>
<td></td>
<td>Large pore volume</td>
<td>Vol %</td>
<td>&gt;10</td>
</tr>
<tr>
<td>Nutrients</td>
<td>P retention</td>
<td>%</td>
<td>&lt;75</td>
</tr>
<tr>
<td></td>
<td>Exchangeable K</td>
<td>me/100 g</td>
<td>&gt;0.5</td>
</tr>
<tr>
<td></td>
<td>Total Zn</td>
<td>ppm</td>
<td>&gt;0.5</td>
</tr>
<tr>
<td></td>
<td>Total Cu</td>
<td>ppm</td>
<td>&gt;0.2</td>
</tr>
<tr>
<td></td>
<td>Total Fe</td>
<td>ppm</td>
<td>&gt;4.5</td>
</tr>
<tr>
<td></td>
<td>Total Mn</td>
<td>ppm</td>
<td>&gt;2</td>
</tr>
<tr>
<td></td>
<td>Total B</td>
<td>ppm</td>
<td>&gt;0.4</td>
</tr>
<tr>
<td>Land Use Requirement (LUR)</td>
<td>Measurement parameter</td>
<td>Units</td>
<td>Range of values</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>---------------------------------------------</td>
<td>--------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Rooting conditions and soil workability</td>
<td>Topsoil depth</td>
<td>cm</td>
<td>S1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&gt;40</td>
</tr>
<tr>
<td></td>
<td>Total effective soil depth</td>
<td>cm</td>
<td>&gt;75</td>
</tr>
<tr>
<td></td>
<td>Topsoil consistency</td>
<td></td>
<td>Loose or friable</td>
</tr>
<tr>
<td>Inundation hazard</td>
<td>Period of inundation during growing season</td>
<td>Days</td>
<td>0</td>
</tr>
<tr>
<td>Frost hazard</td>
<td>Frequency</td>
<td></td>
<td>&gt;1 in 10 years</td>
</tr>
<tr>
<td>Pest and diseases</td>
<td>Nematodes (Meloidogyne incognita) and others</td>
<td></td>
<td>Absent</td>
</tr>
<tr>
<td>Erosion hazard</td>
<td>Degrees</td>
<td></td>
<td>0-10</td>
</tr>
</tbody>
</table>

1. Ratio of precipitation (P) to potential evapotranspiration (E	extsubscript{p}).
2. Insufficient information.
Absence of physical impedance to root growth is especially important for root crops such as sweet potato. As the soil properties which determine how this requirement is met are also important for soil cultivation, these two LURs are treated together. The depth of organic-rich topsoil, the topsoil consistency, and the total effective soil depth that can be exploited by roots are important considerations in assessing rooting conditions and soil workability.

Occurrences of water inundation or frost are obvious hazards to crop production which affect certain areas of Southern Highlands Province. Frost scorches the leaves and damages tubers which commonly become infected with black rot (Ceratocystis fimbriata). Inundation for continuous periods longer than several days kills the plant due to oxygen starvation. Assessment of these hazards is based on estimated frequency of occurrences.

Incidence of pests and diseases commonly limit sweet potato production, and the severity of incidence is often determined by environmental conditions. The sweet potato weevil (Cylas formicarius) is widespread, but tends to be more of a problem during dry periods. Conversely leaf scab (Elsinoe batatas) is more serious in wetter areas. Nematodes (particularly Meloidogyne incognita) are more active in friable, freely drained soils, with populations building up during prolonged periods of cultivation. At this time, only nematode incidence is used as a factor in evaluation, as data on the effects of other important pests and diseases are less available in the Southern Highlands Province.

The hazard of erosion is determined by a number of environmental factors including rainfall erosivity, soil erodibility, slope and management practices. Relatively complex models have been developed for erosion prediction (e.g. Wishchmeier and Smith 1965; Elwell 1980). Slope is frequently the overriding factor in erosion prediction and it is commonly used as an assessment parameter in simplified evaluations such as the present one.

**Step 4. Define critical limits for LURs**

Limits to classes of LUR measurement parameters are suggested in Table 1 based on published information and the field observations of AFTSEMU. Ranges of values are grouped into three land suitability ratings (LSRs) as follows:

- **S1**: highly suitable  
  (equivalent to 80-100 per cent of maximum yield in the absence of other limitations);

- **S2**: moderately suitable  
  (40-80 per cent maximum yield); and

- **S3**: marginally suitable  
  (20-40 per cent maximum yield).
Parameter values falling outside the ranges specified above indicate conditions which are not suitable:

N: not suitable (0-20 per cent maximum yield).

It may be seen from Table 1 that critical values for some LURs are specified for all grades of suitability (from S1 to S3), whereas others may only include specifications for S1 and S2. This is due to the fact that individual requirements differ in the magnitude of their effects on performance. For example, a topsoil depth of less than 10 cm or a period of inundation of more than five days during the growing season may result in extremely poor performance or death of the crop, and is sufficient to warrant an LSR of not suitable (N). However deficiency of a particular trace element, because of the low level of management, may result in a relatively minor yield decrease and thus the LSR may be downgraded to S2, moderately suitable.

For reasons of clarifying the methodology, Table 1 deliberately simplifies the assessment of such requirements as supply of moisture and nutrients, and does not consider variations in specific requirements over the cultivation cycle or the growth of the crop, as is the case in the evaluations currently being carried out by AFTSEMU. It is also expected that some of the class limits suggested in Table 1 will be changed as more information becomes available.

Step 5. Definition of LMUs

The land mapping units are located on the four experimental farms operated by AFTSEMU in the Southern Highlands Province. Figure 4 shows the location of these experimental farms, and Table 2 gives details of each LMU, together with the area occupied within the farm.

With the exception of Pomiorine, which comprises mainly a dissected volcanic footslope, all the farms are situated on gently sloping alluvial or colluvial landforms and all have soils which are originally derived from volcanic ash parent materials. All except Kuma are located in the heavily populated mid-altitude range of the province at 1500-1700 m above sea level. Pomiorine is located in a significantly higher rainfall zone than the other three sites.

Step 6. Selection of land parameters corresponding to LURs

Values for the land properties corresponding to the LURs listed in Table 1 are given for each of the four LMUs in Table 3. The length of the growing season of sweet potato is taken as six months at Pomiorine, Piwa and Kiburu, and nine months at Kuma. For the assessment of total moisture requirements, half the total annual rainfall is taken for the first three sites and three quarters of the annual rainfall for Kuma.
Figure 4. Locations of experimental farms operated by the Agricultural Field Trials, Studies, Extension and Monitoring Unit (AFTSEMU) of the Southern Highlands Rural Development Project (SHRDP).
### Table 2. General description of Land Mapping Units (LMUs).

<table>
<thead>
<tr>
<th>LMU</th>
<th>Farm</th>
<th>Co-ordinates</th>
<th>Elevation (m asl)</th>
<th>Median annual rainfall (mm)</th>
<th>Land form</th>
<th>Slope</th>
<th>Parent material</th>
<th>Soil Series</th>
<th>USDA Soil Class</th>
<th>Area (ha)</th>
<th>% of farm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pm1</td>
<td>Pomiorine</td>
<td>6°23' 144°08'</td>
<td>1560</td>
<td>4914</td>
<td>Moderately dissected volcanic foot slopes</td>
<td>2-8</td>
<td>Airfall volcanic ash</td>
<td>Pangia</td>
<td>Typic Hydrandepts</td>
<td>8.3</td>
<td>58</td>
</tr>
<tr>
<td>Pw1</td>
<td>Piwa</td>
<td>5°52' 142°58'</td>
<td>1610</td>
<td>2449</td>
<td>Cover flood plain and levee of Piwa River</td>
<td>0-1</td>
<td>Alluvially resorted volcanic ash</td>
<td>Piwa</td>
<td>(Aquic Entic Udic Eutrandepts)</td>
<td>5.9</td>
<td>47</td>
</tr>
<tr>
<td>Kb1</td>
<td>Kiburu</td>
<td>6°23' 144°08'</td>
<td>1680</td>
<td>2838</td>
<td>Older terrace of Mendi River</td>
<td>1-3</td>
<td>Alluvially resorted volcanic ash</td>
<td>Kiburu</td>
<td>Aquic Eutrandepts/Dystrandepts</td>
<td>6.7</td>
<td>60</td>
</tr>
<tr>
<td>SU5</td>
<td>Kuma</td>
<td>6°23' 144°08'</td>
<td>2170</td>
<td>&gt;3000</td>
<td>Collo­alluvial fan</td>
<td>0-3</td>
<td>Collo­alluvially resorted volcanic ash</td>
<td>Kuma</td>
<td>Typic Hydrandepts</td>
<td>0.3</td>
<td>13</td>
</tr>
</tbody>
</table>

Note:  
Pm1 data from Pangia (6°21'S, 144°7'E; 1620 masl) for 8 years between 1961 and 1970;  
Pw1 data from Tari (5°52'S, 142°55'E; 1600 masl) for 15 years between 1952 and 1970;  
Kb1 data from Mendi (6°9'S, 143°39'E; 1675 masl) for 12 years between 1951 and 1970 (after McAlpine, Keig and Short (1975)).  
SU5 data: an informed guess.
### Table 3. Land Mapping Units properties used to assess Land Use Requirements (LURs).

<table>
<thead>
<tr>
<th>Land Use Requirement</th>
<th>Assessment Parameter</th>
<th>Units</th>
<th>Land Mapping Unit</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pm1</td>
<td>Pw1</td>
</tr>
<tr>
<td>Energy</td>
<td>Mean annual temperature</td>
<td>°C</td>
<td>19.1</td>
<td>18.1</td>
</tr>
<tr>
<td>Moisture</td>
<td>Median annual rainfall</td>
<td>mm</td>
<td>2457</td>
<td>1224</td>
</tr>
<tr>
<td></td>
<td>Frequency of significant drought</td>
<td></td>
<td>1 in 10 years</td>
<td>1 in 10 years</td>
</tr>
<tr>
<td>Oxygen</td>
<td>Annual P/E₁&lt;sup&gt;1&lt;/sup&gt;</td>
<td>-</td>
<td>3.1</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td>Soil large pore volume</td>
<td>Vol %</td>
<td>11</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>P retention</td>
<td>%</td>
<td>97</td>
<td>95</td>
</tr>
<tr>
<td></td>
<td>Exchangeable K me/100 g</td>
<td></td>
<td>0.30</td>
<td>0.19</td>
</tr>
<tr>
<td></td>
<td>Extractable Zn ppm</td>
<td></td>
<td>0.68</td>
<td>0.55</td>
</tr>
<tr>
<td></td>
<td>Extractable Cu ppm</td>
<td></td>
<td>3.9</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td>Extractable Mn ppm</td>
<td></td>
<td>1.4</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td>Extractable Fe ppm</td>
<td></td>
<td>92</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>Extractable B ppm</td>
<td></td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Nutrients</td>
<td>Topsoil depth</td>
<td>cm</td>
<td>17</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Effective depth</td>
<td>cm</td>
<td>&gt;100</td>
<td>&gt;100</td>
</tr>
<tr>
<td></td>
<td>Topsoil consistence</td>
<td>-</td>
<td>Friable</td>
<td>Friable</td>
</tr>
</tbody>
</table>

Note 1: estimates.
Note 2: Surface horizon.

Topsoils Pm1 and K61: means from two profiles; Pw1 mean from three profiles; SUS5 one profile.
Table 3.  

<table>
<thead>
<tr>
<th>Land Use Requirement</th>
<th>Assessment Parameter</th>
<th>Units</th>
<th>Land Mapping Unit</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pm1</td>
<td>Pw1</td>
</tr>
<tr>
<td>Inundation hazard</td>
<td>Inundation hazard</td>
<td>-</td>
<td>None</td>
<td>2-4 days per year</td>
</tr>
<tr>
<td>Frost hazard</td>
<td>Frost hazard</td>
<td>-</td>
<td>&lt;1 in 10 years</td>
<td>&lt;1 in 10 years</td>
</tr>
<tr>
<td>Pests and diseases</td>
<td>Nematode infestation</td>
<td>-</td>
<td>Moderate</td>
<td>Severe</td>
</tr>
<tr>
<td>Erosion hazard</td>
<td>Slope</td>
<td>Degrees</td>
<td>2-8</td>
<td>1-2</td>
</tr>
</tbody>
</table>

1. Ratio of Precipitation to potential evapotranspiration.

Note 1. Estimated as the median of annual maximum and minimum values calculated using the following altitude/temperature regressions. Max temp = 0.00672 x alt (masl) + 35.0. Min temp = 0.00535 x alt (masl) + 22.0 (McAlpine, Keig and Falls 1983).

Note 2. Rainfall - see Note 1 of Table 2.
E from Mt Hagen (5°52'S; 144°14'E; 1630 m) for Kbl, Pw1 and Pm1 and from Tambul (5053’N; 143057’E; 2340 m) for SU5.
Step 7. Matching land properties with LURs

By comparing the land criteria values in Table 3 with the ranges of critical values in Table 1, a land suitability rating (S1, S2, S3 or N) is derived for each LMU with respect to each LUR. When more than one parameter is used to assess a single requirement, the most limiting parameter is used for the assessment. Table 4 gives the results of this matching process.

### Table 4. Land Suitability Rating (LSR) in respect of Land Use Requirements (LURs) on four Land Mapping Units (LMUs).

<table>
<thead>
<tr>
<th>Land Use Requirements</th>
<th>Land Suitability Rating for LMU&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pm1</td>
<td>Pw1</td>
</tr>
<tr>
<td>Energy</td>
<td>S1</td>
<td>S1</td>
</tr>
<tr>
<td>Moisture</td>
<td>S1</td>
<td>S1</td>
</tr>
<tr>
<td>Oxygen</td>
<td>S2</td>
<td>S1</td>
</tr>
<tr>
<td>Nutrients</td>
<td>S3</td>
<td>S2</td>
</tr>
<tr>
<td>Rooting conditions and soil workability</td>
<td>S3</td>
<td>S3</td>
</tr>
<tr>
<td>Inundation hazard</td>
<td>S1</td>
<td>S2</td>
</tr>
<tr>
<td>Frost hazard</td>
<td>S1</td>
<td>S1</td>
</tr>
<tr>
<td>Pests and diseases</td>
<td>S3</td>
<td>S3</td>
</tr>
<tr>
<td>Erosion hazard</td>
<td>S1</td>
<td>S1</td>
</tr>
</tbody>
</table>

<sup>1</sup>Land Mapping Unit.  <sup>2</sup>P - Rainfall; $E_t$ - potential evapotranspiration.
Step 8. Review to optimise LSRs

At this stage it may be appropriate to review the LSRs, identify those which are most limiting and see if it is possible by modifying the specifications of the LUT (e.g. by adding more physical inputs) or by physically modifying the land (e.g. by drainage) to improve the LSR. This is part of the feedback process that is essential in land evaluation. Altering the specification of the LUT requires that the improved LUT be redefined and presented in the results of the evaluation. By scanning the data in Table 4 we can immediately identify that adverse soil nutrient conditions seriously limit the LSRs of LMUs Pm1 and SU5, whereas 'rooting conditions and workability' are found to be seriously limiting in Pm1 and Pw1.

From Table 2 the source of these limitations can be identified more exactly: Pm1 and SU5 have serious problems of phosphate retention, which is associated with a dominance of short range order minerals in the clay fraction (Uehara and Gillman 1980). Additionally, soil analyses of Pm1 indicate possible deficiencies of manganese and boron, and all LMUs have suboptimal levels of exchangeable potassium. The other major limitations are rooting conditions and workability on Pm1 and Pw1, which is a product of shallow topsoil depth, and severe nematode infestation on Pw1. Can any of these deficiencies be corrected to upgrade the LSR? The obvious limitation to consider for correction is that of nutrient supply. Could this limitation be corrected by adding physical inputs in the form of organic or inorganic fertilisers?

Trials on Pm1 and SU5 failed to show significant responses to N, P, or K treatments at moderate rates of fertilisation, and the results of compost trials are not yet available on all sites. The lack of yield response is probably due to very high fixation of phosphate, and adverse ratios of exchangeable cations affecting P and K uptake. We can conclude, therefore, that addition of inorganic fertilisers at normal rates of application would not be sufficient to upgrade the LSR of S3 for LMUs Pm1 or SU5. Only Pw1, which has a moderate LSR with respect to nutrient supply, shows a significant response to potassium fertiliser at 400 kg K₂O per hectare. Even if is were economic to apply fertiliser at this moderately high rate, the increase in yield (50 per cent) would not be sufficient to upgrade the LSR from S2 to S1.

Step 9. Combine LSRs to give LSC

In Step 7, a series of LSRs was compiled for each LUT/LMU match. In Step 8 the possibility of upgrading the LSRs which were most limiting was investigated by changing the specifications of the LUT (i.e. by adding fertiliser). In Step 9, LSRs are combined to give an overall classification of the suitability of a particular LMU for a particular LUT.

Food and Agriculture Organisation of the United Nations (in press) does not lay down any firm rules about how LSRs should be combined. However it suggests approaches based on either subjective combination, limiting conditions, or
arithmetic procedures. The present author favours the last method, which is described below.

Each LSR is assigned a value as follows:

\[
\begin{align*}
S_1 : 1.0 & \quad S_2 : 0.8 & \quad S_3 : 0.5 & \quad N : 0.0
\end{align*}
\]

These values are then multiplied, and the product, or Land Suitability Index (LSI), is converted to an overall land suitability class using the following scale:

<table>
<thead>
<tr>
<th>Class</th>
<th>LSI values</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1 highly suitable</td>
<td>1.0 - 0.8</td>
</tr>
<tr>
<td>S2 moderately suitable</td>
<td>0.8 - 0.4</td>
</tr>
<tr>
<td>S3 marginally suitable</td>
<td>0.4 - 0.2</td>
</tr>
<tr>
<td>N not suitable</td>
<td>0.0 - 0.2</td>
</tr>
</tbody>
</table>

The LSI limits, between land suitability classes, correspond to the yield scale given for rating LUR measurement parameter values in Step 4. It should be noted that an LSR rating of N, indicating a very serious limitation with respect to a particular requirement, automatically reduces the LSI to 0.0.

Allocation of the suggested values to the LSRs in Table 4, and multiplication to give LSIs for traditional sweet potato production, gives the results shown in Table 5.

**Step 10. Review and field check**

After combining LSRs into LSCs a further check may be required to see if the LSCs can be improved by manipulating any factors which may have been overlooked in Step 8.

**Table 5. Land suitability of four Land Mapping Units (LMUs) for sweet potato production using unimproved traditional techniques.**

<table>
<thead>
<tr>
<th>Land Mapping Unit</th>
<th>Land Suitability Index</th>
<th>Land Suitability Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pml</td>
<td>0.16</td>
<td>N</td>
</tr>
<tr>
<td>Pwl</td>
<td>0.16</td>
<td>N</td>
</tr>
<tr>
<td>Kbl</td>
<td>0.51</td>
<td>S2</td>
</tr>
<tr>
<td>SU5</td>
<td>0.26</td>
<td>S3</td>
</tr>
</tbody>
</table>
The final stage is to submit the provisional LSCs to a field check, preferably by revisiting the sites along with agronomists, extension officers and farmers. Limiting properties of the soil and land should be rechecked and explained to farmers, and the LSCs should be compared with any crop yield data.

Accurate estimates of yields are rarely available on food crop plots managed mainly for subsistence, and there are additional difficulties in estimating the yield of a crop such as sweet potato which is harvested sequentially. The present example is exceptional in that it evaluates LMUs on experimental farms where yield data are available from experiments carried out under controlled conditions.

The most accurate way to check the results of land evaluation with yield data is to compare the values of the Land Suitability Index with recorded yields and to see if there is any statistical correlation between them, or with elements that are not expected to have a direct effect on yield (e.g. erosion hazard, frost hazard). If the latter are found then these elements should be excluded, and a modified LSI recalculated on the basis of direct yield-controlling factors only. Table 6 compares modified LSIs with control (no fertiliser) sweet potato yields on LMUs.

Table 6. Modified Land Suitability Indices (LSIs) and control sweet potato yields on Land Mapping Units (LMUs).

<table>
<thead>
<tr>
<th>Land Mapping Unit (LMU)</th>
<th>Modified Land Suitability Index (LSI)</th>
<th>Sweet potato yield (tonnes/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pm1</td>
<td>0.16</td>
<td>6.8; 7.6; 8.5</td>
</tr>
<tr>
<td>Pw1</td>
<td>0.20</td>
<td>7.5; 8.2; 12.6</td>
</tr>
<tr>
<td>Kb1</td>
<td>0.51</td>
<td>13.8; 21.6; 34.6; 34.7; 38.8</td>
</tr>
<tr>
<td>SU5</td>
<td>0.32</td>
<td>9.4; 13.3</td>
</tr>
</tbody>
</table>

Note: Yields are averages from a number of cultivars, and figures refer to single harvest at six months after planting on Pm1, Pw1 and Kb1. On SU5, tubers take significantly longer to mature, and the yield figures are derived by multiplying 8 month and 9 month yields (from separate trials) by 3/4 and 2/3 respectively to give a six month production estimate comparable with data for the other LMUs.
A linear regression of the modified LSIs against mean yield gives a coefficient of determination \( r^2 \) of 0.68 indicating a trend between modified LSI and observed yield which is significant (P<0.01). Thus 68 per cent of the variation in sweet potato yield on the experimental plots can be explained by the Land Suitability Index derived by the procedures of land evaluation. This result indicates that the assumptions made in the evaluation are essentially correct. A more detailed interpretation of the land data is currently being attempted by AFTSEMU, and this should strive to achieve an even closer agreement with actual yield figures.

It is stressed that, while the methodologies of land evaluation can be applied at any level of detail, the accuracy of the final result will depend on the amount and quality of the data available, and on a knowledge of crop responses to environmental variables. Sweet potato is genetically a very variable crop with a range of environmental responses that are not yet fully understood, but the present study had access to relatively detailed land data which at least partially explains the satisfactory result. If, for example, data on nematode incidence was omitted from the evaluation, Pw1 would be upgraded to S3, and \( r^2 \) in the LSI/yield regression would be reduced to 0.50.

**Steps 11 and 12. Analysis of economics and environmental impact**

These procedures will not be required in all evaluations. If an LUT involving commercial production of food crops, whether on a large scale or a smallholder basis, is being evaluated, it may be appropriate to carry out a financial and/or economic analysis. There are standard techniques for doing this and their discussion is beyond the scope of this paper. It must be stressed that collection and interpretation of socioeconomic data should be an integral part of defining LUTs (Step 2). Apart from considering hazards of erosion, which should be included in every evaluation, the possible impact of increased food production on the environment is too broad a topic to permit detailed discussion here.

**Step 13. Presenting the results of the evaluation**

However complex the procedures in land evaluation, it is essential that the results are clearly and unambiguously stated in terms readily understandable to the user. There has previously been considerable criticism of soil surveyors by agronomists and planners who argue that soil surveys do not provide them with utilisable data, and this criticism is part of the justification for the proposed method of land evaluation.

What information can be presented from this evaluation which will directly benefit the user? The net result of the evaluation is an estimate of the suitability of a defined type of land (the LMU) for a particular type of use (the LUT). This suitability is expressed as a land suitability class (LSC) as in Table 5. For each LSC we can give additional information on expected yield levels, acting limitations, any special soil management conditions, and response to any improved management. Additionally the distribution of each LMU should be mapped.
The results of the evaluation, which should be of direct use to the planner or farmer, are summarised in Table 7. Maps are currently in preparation by AFTSEMU showing the distribution of each LMU on the four experimental farms.

The results of the evaluation must be supported by a full technical report explaining methods of data collection and, in particular, the series of assumptions from which the results are derived. The distribution of the LMUs evaluated should be shown on maps at scales appropriate to the objective of the evaluation.

Table 7. Land suitability classification of Land Mapping Units (LMUs).

<table>
<thead>
<tr>
<th>LMU&lt;sup&gt;1&lt;/sup&gt;</th>
<th>LSC&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Limiting land properties&lt;sup&gt;3&lt;/sup&gt;</th>
<th>Expected yield&lt;sup&gt;4&lt;/sup&gt; (t/ha)</th>
<th>Management practices&lt;sup&gt;5&lt;/sup&gt;</th>
<th>Response to inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pm1</td>
<td>N</td>
<td>N, D, w, x</td>
<td>&lt;9</td>
<td>Mounding, barets</td>
<td>Not significant</td>
</tr>
<tr>
<td>Pw1</td>
<td>N</td>
<td>D, X, n, f</td>
<td>&lt;9</td>
<td>Mounding, barets</td>
<td>50 per cent yield increase over control using 400 Kg K₂O/ha</td>
</tr>
<tr>
<td>Kb1</td>
<td>S2</td>
<td>n, d, x</td>
<td>21-46</td>
<td>Mounding</td>
<td>Not significant</td>
</tr>
<tr>
<td>SU5</td>
<td>S3</td>
<td>N, t, w, c</td>
<td>9-21</td>
<td>Mounding, barets</td>
<td>Not significant</td>
</tr>
</tbody>
</table>

<sup>1</sup>Land mapping unit.  
<sup>2</sup>Land Suitability Class.  
<sup>3</sup>Codes adapted from Purnell (1978) as follows:  
  \( t = \) temperature; \( w = \) oxygen supply to roots; \( n = \) nutrient supply;  
  \( d = \) rooting conditions/workability; \( f = \) inundation hazard;  
  \( c = \) climatic hazard (frost); \( x = \) pests or diseases (nematodes).

A capital letter indicates a serious limitation (LSR = S3); a lower case letter indicates a moderate limitation (LSR = S2).

<sup>4</sup>Expected yields are calculated from the linear regression of modified LSI against yield, using the modified LSI to define class limits as follows:  
  LSI 1.0 - 0.8: S1; 0.8 - 0.4: S2; 0.4 - 0.2: S3; <0.2: N.

<sup>5</sup>These management practices serve to reduce the risk of waterlogging in the root zone and to concentrate the more fertile topsoil within the area exploited by roots. These practices are part of traditional land husbandry and the evaluation assumes that they will be carried out.
APPLYING THE RESULTS OF LAND EVALUATION

As pointed out in the introduction, the prime purpose of land evaluation is to provide a rational basis for taking land use decisions. Using our example from the Southern Highlands we will examine how the results of this evaluation can be used to define priorities for research and extension on the experimental farms.

The summary of results in Table 7 is used as the basis for decision making. With the exception of SU5, the LMUs which are evaluated represent the dominant land type on the farm. For clarity, it is assumed that decisions for the farm as a whole can be made on the basis of evaluation of these LMUs.

At present the experimental farms of Pomiorine, Piwa, Kiburu and Kuma are managed by AFTSEMU for the purposes of basic and adaptive agronomic research and for multiplication of planting material of a number of crops, including sweet potato, for distribution to farmers. On the basis of the results of the land evaluation given in Table 7 the following deductions and recommendations could be made.

1. Pomiorine is classified as not suitable for sweet potato production on the basis of serious nutritional problems and shallow topsoil depth. Neither of these deficiencies is easy to correct (e.g. by normal levels of fertiliser application). However Pomiorine is located on airfall volcanic ash soils which are representative of large areas of the province and there is therefore a strong case for maintaining Pomiorine as a centre for adaptive research aimed at investigating possible improvements in this extensive soil type by cultivar selection, improved crop husbandry or inputs.

2. Piwa is also classified as not suitable, in this case due to shallow topsoil depth and severe nematode infestation. A recent survey (unpublished results) has indicated that nematode infestation is very common in Southern Highlands Province, and an obvious priority would be to conduct trials on nematode control at Piwa. If efficient control could be economically established, the LSC of Piwa would be raised to S3.

3. Kiburu is the most suitable of the four stations for growing sweet potato, and is therefore the best centre for any basic research, plant breeding, and multiplication of planting materials.

4. As for Pomiorine and Piwa, Kuma could be recommended for adaptive research into crop productivity by focussing on the limitations identified in Table 7. It is the only station significantly affected by frost hazard, and particular attention could be given to techniques for ameliorating the effect of frost.

Any recommendations, based on physical observations and assumptions must, of course, be reconciled with provincial and national objectives in deciding the future role of the farms.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAND</td>
<td>an area of the earth's surface, the characteristics of which embrace all reasonably stable, or predictably cyclic, attributes of the biosphere vertically above and below this area, including those of the atmosphere, the soil and underlying geology, the hydrology, the plant and animal populations, and the results of past and present human activity, to the extent that these attributes reflect the uses of the land by man (FAO 1976).</td>
</tr>
<tr>
<td>LAND EVALUATION</td>
<td>the process of assessment of land performance when used for specified purposes.</td>
</tr>
<tr>
<td>LAND SUITABILITY</td>
<td>the fitness of a given type of land for a specified kind of land use (FAO 1976).</td>
</tr>
<tr>
<td>LAND SUITABILITY CLASS (LSC)</td>
<td>a division of land suitability, distinguishing lands which differ in their degree of suitability.</td>
</tr>
<tr>
<td>LAND SUITABILITY INDEX (LSI)</td>
<td>an index of land suitability derived by multiplying values assigned to land suitability ratings.</td>
</tr>
<tr>
<td>LAND SUITABILITY RATING (LSR)</td>
<td>a rating of how well a particular land property or set of properties satisfies a particular requirement of a specified land utilisation type.</td>
</tr>
<tr>
<td>LAND (MAPPING) UNIT (LMU, LU)</td>
<td>an area of land possessing specified properties that can be demarcated on a map.</td>
</tr>
<tr>
<td>LAND USE REQUIREMENT (LUR)</td>
<td>the conditions of land necessary or desirable for successful and sustained practice of a given land utilisation type (of crop requirements, management requirements, conservation requirements).</td>
</tr>
<tr>
<td>LAND USE SYSTEM</td>
<td>a specified land utilisation type practised on a given land unit and associated with inputs, outputs, and possibly land improvements.</td>
</tr>
<tr>
<td>LAND UTILISATION TYPE</td>
<td>a type of land use comprising a crop, crop combination or farming system with a specified technological and socio-economic setting.</td>
</tr>
</tbody>
</table>
ACKNOWLEDGEMENTS

Thanks are due to the Food and Agriculture Organisation of the United Nations for permission to quote from unpublished reports, and to my colleagues in AFTSEMU for useful comments on this paper and for access to previously unreported data.

REFERENCES


THE VALUE OF THE NATIVE PIG AS A MEAT PRODUCER

G.L. Malynicz

Department of Primary Industry,
Konedobu, National Capital District

ABSTRACT

Growth, food consumption, carcass characteristics, and carcass composition were compared for native village pigs and Berkshires. Native pigs grew more slowly, ate more feed, had shorter carcasses, thicker backfat, less muscle and more fat and attracted a lower price. It was considerably more economic to produce lean meat from Berkshires than from native pigs.

INTRODUCTION

Densley et al. (1978) estimated that there are 1.4 million village pigs in Papua New Guinea (PNG). They constitute the single largest livestock resource and source of animal protein. The native pig is tough and well adapted to the rigors of village life. The data described in this paper were collected as part of a larger study to determine the potential of the native pig for production under relatively modern intensive husbandry and feeding.

MATERIALS AND METHODS

The experiment was conducted between 1974 and 1975. Twelve native and seventeen Berkshire pigs from a number of different litters and different parents were raised to a commercial killing live weight of 65 kilograms. Males were castrated after weaning at six weeks.

The sows farrowed in concrete pens fitted with heated creep areas. Piglets were injected with iron dextran against anaemia. At three weeks, piglets were moved to follow-on pens where they received commercial creep feed. After weaning and until 14 weeks, pigs were housed in individual pens with ad-libitum feed and water. From 14 weeks of age to slaughter, pigs were housed in groups and taken out twice daily (once on Sundays) for individual unrestricted feeding. Records were kept of all food consumed from weaning to slaughter.

Pigs were slaughtered by stunning and bleeding. After evisceration, carcasses were hung for 24 hours. During this time they were examined by two commercial
butchers in Goroka and priced. The carcasses were then split, measured, cut into joints and dissected into skin, bone, muscle and fat.

RESULTS AND DISCUSSION

The results obtained are shown in Table 1. Native pigs showed statistically significant differences in growth rate, feed consumption, carcass length, and backfat at "C"; they grew more slowly, ate more food, were less efficient converters of food into weight gain and muscle and had shorter and fatter carcasses. The carcass characteristics were reflected in the price paid by the butchers which was about ten per cent lower for the native pigs. From a strictly commercial point of view, raising native pigs under these conditions is not economic.

Table 1. Data showing the growth and development of native and Berkshire pigs under improved conditions.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Native pig</th>
<th>Berkshire</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S.D.¹</td>
</tr>
<tr>
<td>Number of pigs</td>
<td>12</td>
<td>-</td>
</tr>
<tr>
<td>Age at slaughter (days)</td>
<td>281</td>
<td>15.2</td>
</tr>
<tr>
<td>Feed consumption (kg)</td>
<td>279</td>
<td>11.0</td>
</tr>
<tr>
<td>Weight of carcass (kg)</td>
<td>66.4</td>
<td>0.5</td>
</tr>
<tr>
<td>Carcass length (cm)</td>
<td>64.9</td>
<td>0.36</td>
</tr>
<tr>
<td>Back-fat at &quot;C&quot; (cm)</td>
<td>3.8</td>
<td>0.17</td>
</tr>
<tr>
<td>Weight of skin (kg)</td>
<td>1.41</td>
<td>0.076</td>
</tr>
<tr>
<td>Weight of bone (kg)</td>
<td>9.93</td>
<td>0.227</td>
</tr>
<tr>
<td>Weight of muscle (kg)</td>
<td>9.93</td>
<td>0.267</td>
</tr>
<tr>
<td>Price, Butcher A (t/kg)</td>
<td>44.0</td>
<td>0.69</td>
</tr>
<tr>
<td>Price, Butcher B (t/kg)</td>
<td>38.9</td>
<td>2.55</td>
</tr>
</tbody>
</table>

¹Standard error.
²a, b, c = significantly different from the native pig at P<0.05, P<0.01 and P<0.001 respectively.
In Table 2 are summarised results of a number of experiments from different parts of the world in which primitive native pigs have been compared at the same weight with introduced commercial breeds. In general, they are similar to the results obtained in the present study with native pigs, showing slow growth rates and poor food conversions associated with excess fat production as shown by backfat measurements. Carcass length was short, reflecting a lack of selection for long carcasses with their profitable loins.

Table 2. Published comparisons of local and exotic pigs slaughtered at the same weight.

<table>
<thead>
<tr>
<th>Country</th>
<th>Breed</th>
<th>Slaughter wt (kg)</th>
<th>A.D.G. (g)</th>
<th>FCR¹</th>
<th>Dressing (%)</th>
<th>Backfat (cm)</th>
<th>Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Africa</td>
<td>Bantu</td>
<td>49</td>
<td>279</td>
<td>-</td>
<td>79</td>
<td>4.1</td>
<td>Combrink (1960)</td>
</tr>
<tr>
<td></td>
<td>Landrace</td>
<td>50</td>
<td>467</td>
<td>-</td>
<td>77</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>Native</td>
<td>89</td>
<td>325</td>
<td>5.12</td>
<td>74</td>
<td>4.8</td>
<td>Phillips and Hsu (1944)</td>
</tr>
<tr>
<td></td>
<td>Hampshire</td>
<td>90</td>
<td>480</td>
<td>4.68</td>
<td>72</td>
<td>4.8</td>
<td></td>
</tr>
<tr>
<td>Thailand</td>
<td>Native²</td>
<td>99</td>
<td>311</td>
<td>4.25</td>
<td>77</td>
<td>5.0</td>
<td>Ratarnasarn and Bhanasiri (1968)</td>
</tr>
<tr>
<td></td>
<td>Exotic²</td>
<td>99</td>
<td>500</td>
<td>-</td>
<td>74</td>
<td>3.8</td>
<td></td>
</tr>
<tr>
<td>Poland</td>
<td>Pulawski</td>
<td>116</td>
<td></td>
<td>-</td>
<td>80</td>
<td>5.1</td>
<td>Zebrowski and Kossakowski (1954)</td>
</tr>
<tr>
<td></td>
<td>Large white</td>
<td>120</td>
<td></td>
<td>-</td>
<td>77</td>
<td>3.7</td>
<td></td>
</tr>
</tbody>
</table>

¹Feed conversion ratio. ²At different locations.

REFERENCES


PERI-URBAN BROILER PRODUCTION

B.J. Bakau, G.P. Bilong, R.E. Abdelsamie and W.E. Nano

Poultry Research Centre, Department of Primary Industry, Labu, near Lae, Morobe Province

ABSTRACT

Broiler production by people living near urban centres has become increasingly popular since live chickens can be sold for a high price. Thus the industry is potentially viable. It is estimated that about one million day-old chickens per year are sold to peri-urban growers, and 0.9 million chickens per year are sold alive at an average body weight of 1.8 kg/bird. Over 90 per cent of a live chicken is edible, compared with about 72 per cent for a processed chicken which is sold frozen. The observed high rate of project failure is due to poor management, over production, and unreliable feed supplies. A management system for small scale broiler projects is suggested. Extension efforts directed to promote this management system, together with organising supplies of feed and day-old chickens should help the industry to expand to the level whereby Papua New Guinea is self-sufficient in broiler production.

INTRODUCTION

Brief Background

Emergence of the broiler industry in Papua New Guinea (PNG) has been described by Densley et al. (1978). Ilimo Farm near Port Moresby and the Niugini Table Birds Company near Lae were the main early developers of the broiler industry. The grower operations in Madang and North Solomons Provinces were later established. The former received 5,000 day old (DO) chickens and the latter 3,000 fertile eggs from Niugini Table Birds Company each week. Other large broiler farms also emerged, notably Warwin Poultry (liquidated) and Hyland Product in Morobe Province, and the Christian Leadership Training College in Western Highlands Province.

It is estimated that the National Poultry Hatchery currently (1983) produces 12 million DO broilers each year from its 150,000 broiler breeders. The initial supplies of DO stock were imported from Australia, and then local firms established their own breeder farms and hatcheries. A limited number of DO broilers were made available to peri-urban broiler projects. About 90 per cent of DO broilers were utilised in commercially related broiler growing operations.
A major boost to smallholder participation in the broiler industry, even though associated with a commercial company, was the availability of IDA credit (restricted to areas around Lae, Morobe Province). The scheme initially involved over 50 projects of 1000-5000 birds per batch. Densley et al. (1978) noted that the number of projects had increased unexpectedly. Recently, however, the number of projects has declined to about 45 projects (G. Mott, personal communication).

**Development of Peri-urban Broiler Projects**

Peri-urban poultry was regarded as a sector having only minor significance. However, it was felt that it could help satisfy the high demand for live chickens and make an impact on the nutritional status of peri-urban and urban dwellers. Problems affecting peri-urban broiler operations are similar to those affecting commercial projects. The research solutions to these problems can be utilised by both sectors. For instance the peri-urban grower scheme maintained by Niugini Table Birds Ltd. in the Morobe Province can benefit from research findings channelled through the company's extension service.

Abdelsamie (1979) considered faulty management practices to be the main cause of high mortality and poor growth rates of broilers among contract growers, and this had a subsequent bearing on the income earned by peri-urban poultry farmers. An alternative management system designed to ensure proper housing, readily available water, sufficient waterers, modified feeding troughs and an inexpensive cold brooding technique, was recommended.

The Poultry Research Centre (PRC) had catered for small growers throughout the country, mainly through its poultry distribution programme (20-100 birds/order). (Small scale growers had found it difficult to obtain small numbers of DO broilers from commercial hatcheries.) With the establishment of the National Poultry Hatchery at Erap in 1980, by-products of grandparent stock (males of damline and excess sireline, Tegels - TM-70) were available for distribution. Through the efforts of the Government Distribution Service and commercial hatcheries, an estimated one million broilers have been distributed throughout the country, of which 90 per cent were assumed to be sold live.

Research activities that were undertaken at the centre and applicable to peri-urban broiler production are discussed below. The centre also maintains an active biological and chemical feed quality control programme, thereby ensuring that locally formulated feed available to growers is of desirable quality.

**THE PERI-URBAN BROILER RESEARCH PROGRAMME**

**Broiler Management Systems**

Smallholder broiler projects performed poorly, either during brooding or post brooding. In this context, it is important that initial preparations (feed, water and brooders) be made before the chickens arrive. In lowland conditions, cold brooding (i.e. utilisation of the chicks' own body heat) is effective in maintaining the
temperature within the recommended requirement for chickens (North 1972). The brooder can be constricted initially, and expanded four days later to allow adequate space per bird.

A simplified method of brooding a small number of DO chickens (20-100 birds), in both highland and lowland conditions, using cardboard boxes, has been recommended. An empty tinned fish or beer carton is adequate to accommodate 40 or 20 chickens, respectively. Chickens are given feed and water in a confined room during the day, and packed into boxes in the late afternoon. In highland areas the boxes have to be taken into the house, and when a fire is lit on cold nights sufficient warmth is provided to the chickens.

Abdelsamie (1979) and Nano et al. (1983a) showed that a substantial reduction in feed intake and a poor growth rate occurred as a result of using incorrect brooding techniques. Dryness of deep litter during brooding is important, since a continuous odor from a low concentration of ammonia affects food conversion efficiency (Reece and Deaton 1981). Mild beak trimming of DO chicken and correct brooding eliminate the possibility of feather pecking causing bare-back, and to an extent improve feed conversion (Table 1). Nano et al. (1983b) found no significant difference when 5, 7 and 10 days brooding were adopted under mainland conditions (Table 2). They suggested 7 days brooding should be adequate.

Broilers are usually marketed at 7-8 weeks of age. High stocking density (0.06 m² per bird) appeared to have no adverse effects in terms of mortality. However, lower density tended to improve body weight (Nano et al. 1983a). Bolton et al. (1970) suggested using a density of 0.047 m² per bird up to 9 weeks of age and a lower density thereafter. These results are in general agreement with our own findings. The lower density appears to be usable, but it is suggested that an allowance of at least 0.08 m² per bird be used under tropical conditions. A higher stocking density is appropriate if some of the birds are to be withdrawn (i.e. the larger birds are sold first) as early as 6 weeks of age.

The recommended change from broiler starter to finisher at 28 days of age was also investigated. Nano (1983) found no difference in performance when the period of using starter feed was reduced from 28 days to as low as 18 days. As the cost of starter feed is higher than that of finisher feed, some savings in feed cost can be made. It is also recommended that when starter feed is not available to peri-urban growers, finisher can be used, providing the pellets are ground before feeding until the chickens are able to consume pellets.

**Broiler Nutrition**

Biological yield from locally manufactured broiler feeds was compared with that of imported feed (Bakau et al. 1983). A high density feed that is manufactured locally (22 per cent crude protein (CP) for starter and 20 per cent CP for finisher) was found to be similar to feed imported from New Zealand. Locally produced ordinary feed (20 per cent CP starter, and 18 per cent CP finisher) was found to
be inferior. Pellet size (5/16 and 5/32 of an inch) did not seem to have an affect on performance (Nano et al. 1983).

Table 1. The effect of brooding and debeaking on broiler performance.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Age (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Cold brooded/not debeaked</td>
<td></td>
</tr>
<tr>
<td>Average body weight (g)</td>
<td>72</td>
</tr>
<tr>
<td>Average feed intake (g)</td>
<td>83.9</td>
</tr>
<tr>
<td>Feed conversion ratio</td>
<td>1.104</td>
</tr>
<tr>
<td>Mortality (per cent)</td>
<td>2.0</td>
</tr>
<tr>
<td>Cold brooded/debeaked</td>
<td></td>
</tr>
<tr>
<td>Average body weight (g)</td>
<td>69</td>
</tr>
<tr>
<td>Average feed intake (g)</td>
<td>79.1</td>
</tr>
<tr>
<td>Feed conversion ratio</td>
<td>1.146</td>
</tr>
<tr>
<td>Mortality (per cent)</td>
<td>2.1</td>
</tr>
<tr>
<td>Warm brooded/not debeaked</td>
<td></td>
</tr>
<tr>
<td>Average body weight (g)</td>
<td>56</td>
</tr>
<tr>
<td>Average feed intake (g)</td>
<td>n.a.</td>
</tr>
<tr>
<td>Feed conversion ratio</td>
<td>n.a.</td>
</tr>
<tr>
<td>Mortality (per cent)</td>
<td>n.a.</td>
</tr>
<tr>
<td>Warm brooded/debeaked</td>
<td></td>
</tr>
<tr>
<td>Average body weight (g)</td>
<td>56</td>
</tr>
<tr>
<td>Average feed intake (g)</td>
<td>87.9</td>
</tr>
<tr>
<td>Feed conversion ratio</td>
<td>1.570</td>
</tr>
<tr>
<td>Mortality (per cent)</td>
<td>6.8</td>
</tr>
</tbody>
</table>

1Not available.  Source: Abdelsamie (1979).
Broilers at 7 weeks of age should have a fully developed body frame. Scott, Nesheim and Young (1976) stated that at about 6 weeks of age the broiler's protein requirement is reduced. Bilong and Abdelsamie (1983) used feed with a low level of protein (12-16 per cent CP) but a higher energy level than commercial feed for raising large size broilers at 7 weeks of age, and found it to be beneficial. It was suggested that in highland areas where large and fat chickens are in great demand, or in situations where a complete sell-out at one time is not possible, commercial rations could be diluted with a low protein ingredient and fed to chickens.

Table 2. The effect of brooding length on broiler body weight, feed intake, feed conversion, and mortality.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>3 days brooding</th>
<th>7 days brooding</th>
<th>10 days brooding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>10</td>
<td>21</td>
<td>35</td>
</tr>
<tr>
<td>Average body weight (g)</td>
<td>113</td>
<td>338</td>
<td>905</td>
</tr>
<tr>
<td>Average feed intake (g)</td>
<td>126</td>
<td>505</td>
<td>1787</td>
</tr>
<tr>
<td>Feed conversion ratio</td>
<td>1.11</td>
<td>1.49</td>
<td>2.01</td>
</tr>
<tr>
<td>Mortality (per cent)</td>
<td>3.34</td>
<td>3.58</td>
<td>4.00</td>
</tr>
</tbody>
</table>

Coon et al. (1981) found that high energy finishing diets (3465 Kcal metabolic energy (ME)) improved feed conversion (P<0.05), and a significant diet x sex interaction was observed. A crude protein level of 13 per cent and a spacing of 0.15 m² per bird were suggested for raising broilers beyond 10 weeks. Sweet potato (*Ipomoea batatas* (L.) Lam.) should not be used as a major substitute in broiler diets (Turner et al. 1976). However, cassava (*Manihot esculenta* Cranz.) root meal comprising up to 50 per cent of the diet may be used (Abdelsamie 1979). Storage of feed for a period of up to nine weeks did not affect chicken performance (Abdelsamie 1979).

The importance of water and the effects of water restriction on all classes of poultry have been reported by numerous authors. In a tropical environment any form of water deprivation adversely affects chickens throughout the rearing period. Higher mortality (P<0.05) was experienced when water was restricted, especially during the brooding period (Abdelsamie and Yadiwilio 1981). Two treatments (5 hour, and alternate day watering) had a detrimental effect (P<0.01) on the broilers. This result is particularly significant for local village situations where social and other commitments take precedence over daily attendance to chickens. This work also demonstrated that broilers in the tropics consume twice as much water as those raised in a temperate climate.

**NUTRITIVE COMPOSITION OF CHICKEN MEAT**

The approximate composition of chicken breasts, wings, legs and thighs are summarised in Table 3. Chicken pieces are greatly preferred to whole processed chicken, but the cost per unit nutritive value is far greater (Abdelsamie 1981c). Breasts have the highest protein and lowest fat content, whereas thighs are high in fat and low in protein. Wings and legs are intermediate. By contrast for chicken sold alive, 90 per cent of the bird is edible, and thus it has a higher nutritive value than the processed chicken (72 per cent dressed weight).

<table>
<thead>
<tr>
<th>Piece</th>
<th>Edible portion (g)</th>
<th>Bone (g)</th>
<th>Crude protein (g)</th>
<th>Fat (g)</th>
<th>Protein cost (t/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breast</td>
<td>437.4</td>
<td>62.6</td>
<td>78.7</td>
<td>30.3</td>
<td>2.10</td>
</tr>
<tr>
<td>Legs</td>
<td>399.8</td>
<td>100.3</td>
<td>50.2</td>
<td>43.2</td>
<td>3.29</td>
</tr>
<tr>
<td>Wings</td>
<td>371.5</td>
<td>128.6</td>
<td>43.9</td>
<td>68.5</td>
<td>3.76</td>
</tr>
<tr>
<td>Thighs</td>
<td>402.6</td>
<td>97.4</td>
<td>24.1</td>
<td>109.8</td>
<td>6.83</td>
</tr>
</tbody>
</table>

Table 3. Nutritive composition of 500 g chicken pieces.
CONSTRAINTS IMPEDING BROILER PRODUCTION

Feed Supplies

Irregularity of feed supply in centres far from Lae has been a problem. Provincial Divisions of Primary Industry should ensure that farmers are assisted to obtain feed. With better coordination, interested farmers will be sufficiently confident to start peri-urban projects. There is also scope for Lae Feed Mills to bag poultry feed in smaller quantities than the conventional 50 kilogram bags, preferably in 15, 20, 25 and 30 kilogram bags. This could have an impact on the general interest in back yard projects for subsistence consumption and in production for live markets.

Extension Support

For peri-urban broiler production to be of any significance, there should be coordinated extension support. Formerly, many research findings were implemented to improve broiler husbandry. However, since the decentralisation process was initiated, the extension service has lost its role of active implementation of research findings. Thus there is now a gap between farmers and researchers. The Poultry Research Centre with its advisory services and inservice training courses offers some solutions. However, there is no alternative to a sound extension service provided by staff who are directly in contact with growers.

Marketing

Peri-urban broiler production is a highly profitable enterprise if undertaken correctly. However, a lack of coordination has resulted in an irregular supply of live chickens to the market. Growers often start a project with a small number of birds. When they obtain a good profit they suddenly increase the numbers. As a result over supply can occur, with a resultant inability to sell their chickens within the period that will give the farmer the maximum return. The chickens are often kept longer than is desirable, and the extra cost of feeding reduces the profit. Thus it is important that the supply of live chickens to the market is regulated.

REFERENCES


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GUINEA PIG: A POTENTIAL SOURCE OF PROTEIN FOR ISOLATED AREAS

W. Nano, G. P. Bilong and R. E. Abdelsamie

Poultry Research Centre, Department of Primary Industry, Labu, near Lae, Morobe Province

ABSTRACT

The potential of guinea pigs as a source of human food is not well known. Two feeding experiments were carried out with guinea pigs at the Labu Poultry Research Centre in Morobe Province, using fresh foliage and broiler finisher. It was found that a broiler finisher supplement was necessary when fresh sweet potato or cassava leaves were the main feedstuff in order to avoid high mortality and to obtain adequate body weight gain. Low capital costs, low labour requirements and rapid multiplication rates make guinea pigs an attractive proposition for rural communities. However further research is necessary to determine appropriate feedstuffs, and to select animals that can survive and produce under low plan nutrition.

INTRODUCTION

Guinea pigs are known throughout the world as house pets, show fanciers and, more importantly, as laboratory animals. Their potential as human food is not very well known. The centre of diversity is in South America, where the archaeological remains suggest that guinea pigs must have been domesticated and used as meat by the ancient Andeans. The authors of this paper strongly believe that the guinea pig has potential as a source of meat in developing countries and particularly in remote areas.

The guinea pig is neither from Guinea nor is it a pig. It is a small South American rodent (15 - 41 cm long) which comes from the order Rodentia, superfamily Cavioidae, family Caviidae, and subfamily Cavies. The guinea pig is in the same order as rats and bandicoots, however it is not in the same family. It has no tail and has a functional caeca. It is herbivorous.

Domestic guinea pigs are classed into three types based on coat characteristics: smooth-short; rough short; and long-hair. The type that is commonly used for meat production is the smooth-short type.
The domesticated guinea pig (*Cavia procellus*), which has developed from at least two wild ancestors (*Cavia aperea* and *Cavia cutleri*), is distributed world-wide. However, the wild types which are living in the natural habitat are restricted to South America, where they are common in the Andean highlands (altiplano or puna) at elevations of 3500 - 4500 m and latitude 15 - 17° S (Loetz *et al.* 1983).

**GUINEA PIGS AS AN IMPORTANT SOURCE OF MEAT**

Guinea pig meat is relatively unknown in this country, due primarily to the emphasis placed on the development of larger farm animals such as cattle and pigs. However, this does not eliminate the guinea pig as a potential source of meat.

Notle (1975) and Jara-Almonte *et al.* (1975) mentioned the significance of the guinea pig as a source of meat in Peru. A total breeding herd of 20,932,000 guinea pigs and a meat production figure of 17,000 tonnes per annum were reported. Zalvidar *et al.* (no date) mentioned that the content of crude protein in guinea pig meat (20 per cent) is higher than that in cattle (17 - 18 per cent), pig (14 per cent), sheep (16 per cent), chicken (18 per cent) and fish (16 per cent).

On the management and production of guinea pigs, excellent papers have been produced by the Departamento Animales Granja (1971) and the Departamento Animales Menores (1971). Marco *et al.* (1972) reported some work on guinea pigs which involved using different numbers per treatment and feeding freshly cut alfalfa and dry alfalfa and concentrates. They found that the best results were obtained from ten guinea pigs in a group.

Zalvidar *et al.* (no date) undertook similar work. They used alfalfa, chala (corn leaf) *ad-libitum*, alfalfa plus concentrate and chala plus concentrate. They achieved over 500 g liveweight from both alfalfa and chala *ad-libitum*, and over 600 g liveweight from both alfalfa plus concentrate and chala plus concentrate, in a period of 56 days. Loetz *et al.* (1983) recommended some good management and production methods for guinea pigs.

Papua New Guinea has abundant sources of grasses. Being largely herbivorous, and having rapid breeding habits and small unit size, guinea pigs can potentially be a good source of protein for isolated areas of the country.

The basic aim of this work was to see if guinea pigs can be raised successfully using green leaves that can be readily obtained by the people as the major source of food.

**MATERIALS AND METHODS**

**Experiment 1**

The experimental design was a 2 (feed treatments) x 2 (sexes) factorial with an uneven number of replicates (5 males and 3 females) per treatment. Sixteen
weaned and sexed guinea pigs (GP), with weaning weights between 150 g and 300 g, were obtained from the breeding stock at the Poultry Research Centre, Lae.

The two treatments were: (1) mixed foliage only (MFO); (2) mixed foliage (MF) plus broiler finisher (BF, 20 per cent crude protein). The MF was cut daily near the research station and prepared two hours before feeding time (0900 - 1100 h.). The predominant species in the MF, ranked in order of abundance, were:

1. Para grass (*Brachiaria mutica*)
2. Legumes (*Calopogonium muconoides* and *Centrosema pubescens*)
3. Some Compositae species.

The guinea pigs were housed individually in cages, with a galvanised tray filled with sawdust (4 - 5 cm thick). Spacing allowed per guinea pig was 0.4 m².

Daily feed and residue samples were obtained throughout the experimental period for chemical analysis. The feed and residual samples were oven-dried (80°C), hammer-milled (Christy 7445) and stored in air-tight plastic bottles for proximate analysis. The AOAC (1963) methods of analysis were used.

Throughout the experimental period, feed and water were offered *ad-libitum*. Weekly body weight, daily feed consumption and mortality records were kept.

**Experiment 2**

The experimental design was a 4 (feed treatments) x 2 (sexes) factorial with 4 replications per treatment. This experiment was initially aimed at comparing the growth performance of guinea pigs on *ad-libitum* fresh sweet potato leaves (SPL), fresh cassava leaves (CL) and fresh mixed foliage (MF).

However due to high mortality and poor growth performance of guinea pigs on mixed foliage only in experiment 1, limited quantities of supplement in the form of broiler finisher were offered as follows:

- **Treatment 1:** SPL *ad-libitum* plus 10 g/day BF
- **Treatment 2:** CL *ad-libitum* plus 10 g/day BF
- **Treatment 3:** MF *ad-libitum* plus 10 g/day BF
- **Treatment 4:** MF *ad-libitum* plus 5 g/day BF

Thirty two weaned and sexed guinea pigs (290 - 420 g weaning weight) were used in this experiment. They were distributed to the four treatments on a stratified random basis according to weights. Four males and four females were assigned to each treatment. All experimental materials were the same as in experiment 1. A one week acclimatisation period was allowed for the guinea pigs, and the experimental period lasted 56 days. Weekly body weight, daily food consumption, feed residues and mortality records were kept.
RESULTS

Experiment 1

The composition of the diets offered are shown in Table 1. Body weight, food intake, food conversion ratio and mortality results are shown in Table 2 and Table 3. The results indicated that the performance of animals in treatment 2 was superior to those in treatment 1. In this experiment, six of the eight guinea pigs in treatment 1 died before the end of the eight week experimental period. It was evident that high mortality was due to inadequate nutrition. Due to high mortality there was insufficient data for statistical analyses.

Experiment 2

The results of the chemical composition of the dietary treatments are shown in Table 4.

Feed Intake

The main daily food intake is presented in Table 5. These results indicate consumption of diet treatment 2 (fresh cassava leaves) was significantly lower than consumption from the other 3 diets (P<0.001). Sex differences were also evident particularly in treatments 1, 3 and 4 where males consumed more food than females (P<0.01). When the sex of the animals was ignored, average food intake in treatments 3 and 4 were significantly higher than those of treatments 1 and 2.

Table 1. Per cent chemical composition of broiler finisher (BF) and mixed foliage (MF) for experiment 1 (air dry basis).

<table>
<thead>
<tr>
<th>Component</th>
<th>BF</th>
<th>MF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter</td>
<td>86.90</td>
<td>18.79</td>
</tr>
<tr>
<td>Crude protein (per cent N x 6.25)</td>
<td>20.35</td>
<td>8.60</td>
</tr>
<tr>
<td>Ether extract</td>
<td>1.20</td>
<td>2.16</td>
</tr>
<tr>
<td>Acid detergent fibre</td>
<td>5.70</td>
<td>33.50</td>
</tr>
<tr>
<td>Ash</td>
<td>7.45</td>
<td>11.10</td>
</tr>
</tbody>
</table>
Body Weight Gain

Body weight gains over the 56 day period were 101.6 g, 62.4 g, 122.8 g and 75.0 g for the four treatments, T1, T2, T3 and T4, respectively (Table 6). These differences were found to be significant (P<0.05). Males gained an average of 96.6 g compared with females which gained an average of 84.3 g. The differences were not significant.

Table 2. **Average daily pellets and foliage intake (air dry basis) for experiment 1.**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Daily pellet intake (g)</th>
<th>Daily foliage intake (g)</th>
<th>Total daily pellet and foliage intake (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T_1^1 (1 M^2)</td>
<td>0</td>
<td>27.80</td>
<td>27.80</td>
</tr>
<tr>
<td>T_1 (1 F^3)</td>
<td>0</td>
<td>27.50</td>
<td>27.50</td>
</tr>
<tr>
<td>T_2 (5 M)</td>
<td>13.68</td>
<td>8.60</td>
<td>22.20</td>
</tr>
<tr>
<td>T_2 (3 F)</td>
<td>13.00</td>
<td>8.15</td>
<td>21.36</td>
</tr>
</tbody>
</table>

^1Treatment 1: SPL ad-libitum plus 10 g/day BF; Treatment 2: CL ad-libitum plus 10 g/day BF. ^2Male. ^3Female.

Table 3. **Mean weekly body weights (g), food conversion ratio and mortality per cent.**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Initial body weight (g)</th>
<th>Days</th>
<th>Gain per day</th>
<th>Mortality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7</td>
<td>14</td>
<td>21</td>
<td>28</td>
</tr>
<tr>
<td>T_1^1 (1 M^2)</td>
<td>180</td>
<td>186</td>
<td>196</td>
<td>116</td>
</tr>
<tr>
<td>T_1 (1 F^3)</td>
<td>173</td>
<td>170</td>
<td>166</td>
<td>120</td>
</tr>
<tr>
<td>T_2 (5 M)</td>
<td>212</td>
<td>227</td>
<td>263</td>
<td>302</td>
</tr>
<tr>
<td>T_2 (3 F)</td>
<td>240</td>
<td>298</td>
<td>298</td>
<td>333</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Food conversion ratio (g food/g gain)</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>T_2 (5 M)</td>
<td>10.2</td>
</tr>
<tr>
<td>T_2 (3 F)</td>
<td>2.7</td>
</tr>
</tbody>
</table>

^1Treatment 1: SPL ad-libitum plus 10 g/day BF; Treatment 2: CL ad-libitum plus 10 g/day BF. ^2Male. ^3Female.
Feed Conversion Ratio (FCR)

The results of feed conversion are given in Table 7. There were no significant differences between the sexes, however there were significant differences between diets. The sex x diet interaction was not significant.

Table 4. Per cent chemical composition of diets (experiment 2): broiler finisher (BF); fresh sweet potato leaves (SPL); fresh cassava leaves (CL); and fresh mixed foliage (MF). (The data are given on an air dry basis.)

<table>
<thead>
<tr>
<th>Component</th>
<th>BF</th>
<th>SPL</th>
<th>CL</th>
<th>MF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter</td>
<td>89.9</td>
<td>8.4</td>
<td>19.2</td>
<td>19.2</td>
</tr>
<tr>
<td>Crude protein (% N x 6.25)</td>
<td>21.7</td>
<td>20.4</td>
<td>21.7</td>
<td>8.9</td>
</tr>
<tr>
<td>Ether extract</td>
<td>3.7</td>
<td>9.5</td>
<td>5.6</td>
<td>8.9</td>
</tr>
<tr>
<td>Acid detergent fibre</td>
<td>6.6</td>
<td>28.8</td>
<td>26.5</td>
<td>36.9</td>
</tr>
<tr>
<td>Ash</td>
<td>7.6</td>
<td>17.7</td>
<td>10.5</td>
<td>9.1</td>
</tr>
</tbody>
</table>

Table 5. Food intake for the four treatments in experiment 2 (see Methods, Experiment 2 Section for details of the treatments).

<table>
<thead>
<tr>
<th>Treatments¹:</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Females</td>
<td>17.3</td>
<td>18.5</td>
<td>37.2</td>
<td>40.3</td>
</tr>
<tr>
<td>Males</td>
<td>23.8</td>
<td>19.6</td>
<td>48.1</td>
<td>41.3</td>
</tr>
<tr>
<td>Average</td>
<td>20.5</td>
<td>19.1</td>
<td>42.6</td>
<td>40.8</td>
</tr>
</tbody>
</table>

¹Treatment 1: sweet potato leaves *ad-libitum*
plus 10 g/day broiler finisher (BF);
Treatment 2: cassava leaves *ad-libitum* plus 10 g/day BF;
Treatment 3: mixed foliage *ad-libitum* plus 10 g/day BF;
Treatment 4: mixed foliage *ad-libitum* plus 5 g/day BF.
DISCUSSION

The combined results of experiments 1 and 2 clearly demonstrated that guinea pigs could not be reared on green leaves alone. A balanced diet was required for optimal growth. These results are in agreement with those of other authors who reared guinea pigs as laboratory animals (Lane-Petter 1971; National Research Council 1972). However, Zalvidar et al. (no date) reported satisfactory growth rates when guinea pigs were fed *ad-libitum* on alfalfa and chala (corn leaves) (see Table 8).

Table 6. **Body weight gain (g) in experiment 2.**

<table>
<thead>
<tr>
<th>Treatments¹:</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Females</strong></td>
<td>89.8</td>
<td>58.8</td>
<td>109.3</td>
<td>79.5</td>
<td>84.3</td>
</tr>
<tr>
<td><strong>Males</strong></td>
<td>113.5</td>
<td>66.0</td>
<td>136.3</td>
<td>70.7</td>
<td>96.6</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>101.6</td>
<td>62.6</td>
<td>122.3</td>
<td>75.0</td>
<td></td>
</tr>
</tbody>
</table>

¹Treatment 1: sweet potato leaves *ad-libitum* plus 10 g/day broiler finisher (BF);
Treatment 2: cassava leaves *ad-libitum* plus 10 g/day BF;
Treatment 3: mixed foliage *ad-libitum* plus 10 g/day BF;
Treatment 4: mixed foliage *ad-libitum* plus 5 g/day BF.

Table 7. **The mean feed conversion ratios by sex and treatment for experiment 2.**

<table>
<thead>
<tr>
<th>Treatments¹:</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Females</strong></td>
<td>11.14</td>
<td>20.32</td>
<td>17.31</td>
<td>24.80</td>
<td>18.39</td>
</tr>
<tr>
<td><strong>Males</strong></td>
<td>11.84</td>
<td>10.45</td>
<td>17.29</td>
<td>33.71</td>
<td>18.32</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>11.49</td>
<td>15.38</td>
<td>17.30</td>
<td>29.29</td>
<td></td>
</tr>
</tbody>
</table>

¹Treatment 1: sweet potato leaves *ad-libitum* plus 10 g/day broiler finisher (BF);
Treatment 2: cassava leaves *ad-libitum* plus 10 g/day BF;
Treatment 3: mixed foliage *ad-libitum* plus 10 g/day BF;
Treatment 4: mixed foliage *ad-libitum* plus 5 g/day BF.
Experiment 1

In treatment 1, when broiler finisher was offered *ad-libitum*, satisfactory growth rates and liveability were achieved. Feeding mixed foliage only (treatment 1) resulted in high mortality and weight loss. Treatment differences were obviously due to differences in nutrient composition (Table 1). The work of Rein *et al.* (1956), Rein (1954a, 1961), Lane-Petter (1971) and National Research Council (1972) are in agreement with this conclusion.

Experiment 2

The high feed intake, when the two mixed foliage diets were fed, may be due to the high fibre levels. High dietary fibre is well known to have a stimulating effect on feed consumption. This has been demonstrated by the work of Zweygarth (1979), using guinea pigs, and Minderia (1981) using pigs.

The higher body weight gain from mixed foliage (MF) plus 10 g broiler finisher (BF) compared to mixed foliage plus 5 g broiler finisher was due primarily to the high level of pelleted food (BF). Although the intake of MF was high (Table 5), the amount of crude protein (Table 4) in MF was too low to support vigorous growth. The lower total weight gain for cassava leaves plus 10 g BF could be due to the presence of hydrogen cyanide (HCN) in the leaves. The high level of HCN in cassava leaves and the effect of HCN on growth are well known (Choo *et al.* 1972; Mahendranathan 1971; Siriwardena *et al.* 1974; and Ranaweera *et al.* 1981).

**Table 8.** Average initial weight, final weight, total weight gain and gain per day (from Zalvidar *et al.* (no date)).

<table>
<thead>
<tr>
<th>Feed treatment</th>
<th>Initial weight (g)</th>
<th>Final weight (g)</th>
<th>Daily wt gain (g/day)</th>
<th>Total wt gain (g)</th>
<th>Duration (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa <em>ad lib.</em></td>
<td>443</td>
<td>578</td>
<td>2.41</td>
<td>135</td>
<td>56</td>
</tr>
<tr>
<td>Alfalfa + concentrate</td>
<td>382</td>
<td>683</td>
<td>5.38</td>
<td>301</td>
<td>56</td>
</tr>
<tr>
<td>Chala (maize foliage) <em>ad lib.</em></td>
<td>400</td>
<td>517</td>
<td>2.08</td>
<td>117</td>
<td>56</td>
</tr>
<tr>
<td>Chala + concentrate</td>
<td>371</td>
<td>657</td>
<td>5.1</td>
<td>286</td>
<td>56</td>
</tr>
</tbody>
</table>
Efficiency of feed conversion in guinea pigs fed mixed foliage plus 5 g broiler finisher was poor compared with other dietary treatments. This also was a direct result of the smaller amount of broiler finisher given. In this treatment, dietary density was lower than that for the other diets.

**CONCLUSION**

Available evidence from the literature suggests that guinea pigs have potential as a source of meat. Loetz *et al.* (1983) attributed this to low capital costs, low labour requirements and a speedy return on investment. Guinea pigs also adapt to a diversity of climatic conditions, they are prolific and have the ability to utilise foodstuffs not normally used by humans. The management and feeding of guinea pigs under village conditions requires further investigation. The present study showed that guinea pigs are unable to survive and produce on diets based solely on greens; the likelihood of feeding other foodstuffs commonly available from the subsistence farming systems in Papua New Guinea is uncertain. It is also possible that the genetic materials used in this study were not suitable.

In this regard, research is continuing to investigate the effect of selection from the base population available at Labu, for animals that can survive and produce under low plan nutrition.

**REFERENCES**


Marco, Benjamin and Jose (1972). *Produccion de Cuyes*. Ministerio de Agricultura, Lima, Peru.


<table>
<thead>
<tr>
<th>Date</th>
<th>Fishes</th>
<th>Estimated number of individuals</th>
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<tr>
<td>January 10</td>
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<tr>
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<td></td>
<td>sardine</td>
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Table 2. Fishes caught near the fish aggregating device.

<table>
<thead>
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<th>Weight (kg)</th>
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<td>4</td>
</tr>
<tr>
<td>Others</td>
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<td>-</td>
<td>50</td>
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</table>

CONCLUSION

The Fish Aggregating Device Project in the Huon Gulf was the first of its kind to be carried out in Papua New Guinea. Although there may be some individuals and institutions doing similar work, nothing has yet been published on the subject. Thus the project conducted in Lae for a period of one year was based on overseas correspondence, and personal contact with the communities and individuals involved.

Overall the project was a success. We have fulfilled our aims of testing the device. The device did indeed aggregate fish. Many fish were attracted including the pelagics, and the numbers were high. The numbers of fishes caught around the device are not discussed here because the fishermen involved were handliners, so they rarely fished for the pelagic.

A few factors relating to fish aggregating devices were encountered during the project, which held up progress. Firstly it was found that planning is very important in a project of this nature. Several times I had to postpone activities due to a lack of availability of materials in Lae or Papua New Guinea. This occurred for polyurethane foam and swivels. These two items had to be purchased from outside Lae. Secondly, permission is required from the Executive Officer of Navigational Aids to deploy the devices to the seas. This is very important because the devices could be a navigational hazard to ships if the authorities were unaware of them.

The cost of building a device was approximately K374.00 (1982 prices), with the anchor line cost being about half the total. Anyone involved in using fish aggregating devices should realise that in order to have a dependable device, secure attachment between the buoy and the anchor line should be provided.

Despite all of these factors discussed, I consider that the fish aggregating device is a very efficient device in the fishing industry, and should be further developed for the exploitation of the pelagic stock by local fishermen.
PART V:
MARKETING & PROCESSING
RECENT AND FUTURE TRENDS IN THE MARKETING OF FRESH FRUIT AND VEGETABLES IN PAPUA NEW GUINEA

Garth Atkinson¹ and Harry Lewis²

¹Department of Primary Industry, Port Moresby
²Central Food Marketing, Port Moresby

ABSTRACT

A review of the marketing of fruit and vegetables in Papua New Guinea (PNG) in the 1960s, and the formation of the Fresh Food Project which subsequently became the Food Marketing Corporation (FMC) is presented. The open markets are responsible for a large part of the fruit and vegetables sold in PNG. Their formation and operation are discussed. In 1981 the Government closed down the FMC, and the assets were sold. In Western Highlands, Morobe and Central Provinces the functions of the FMC were taken over by the Provincial Governments. Since the demise of FMC, farmers have experienced considerable difficulty in marketing their produce. The Central Highlands Produce Company, Niugini Produce Marketing and Central Food Marketing operate independently of each other which results in poor market intelligence. This is compounded by direct transactions between producer and retailer.

A proposal to introduce an import quota system was announced in early 1983. This has stimulated considerable interest among retail and wholesale organisations to buy local produce, but it is unlikely to overcome many of the problems which are preventing the industry from expanding. The future of the existing marketing systems, which has relevance to the factors influencing the costs of producing, wholesaling, and retailing, is considered.

INTRODUCTION

There are three principal methods of marketing fresh fruit and vegetables that are potentially available to the producer in Papua New Guinea (PNG). These are:

(1) the open markets, known in some centres as the local market or council market;
the wholesale markets, three of which in Papua New Guinea are now owned by provincial governments, and others are owned by private enterprise; and
direct selling by the producer to the retailer or end user, for example institutions such as the Police, Defence Force, hospitals, hotels and schools.

OPEN MARKETS

Recent Trends

The method of selling in the open markets has not changed substantially since their inception. The majority of sellers are also producers. Produce is sold in small lots, and priced apparently by volume and not by weight. Bargaining does not occur even with unsold produce remaining at the end of the day.

Sherwin (1965) quoted by McCullough (1971) noted that some men said they were not prepared to take money at any price for fresh produce because there are never any business gardens planted nor any special crops planted for sale. At Koki market in Port Moresby, men and women bring for sale only what is surplus to their needs. Flores and Harris (1982) considered that by 1979 at least, this traditional market mentality was not supported by the evidence. They found that morning and afternoon prices tended to be the same throughout the survey week in each market. However very substantial variation in prices occurred between days in the same market, and substantial differences were found between markets on the same day, and over the week as a whole. Flores and Harris (1982) suggested that "the influence of traditional price setting resulting in inflexible prices has disappeared during the 1970s and has been replaced by price determination which is responsive to demand, supply and cost factors."

The type of produce sold is also changing. Although the markets are still dominated by staples, increasing amounts of locally-grown introduced vegetables are now being sold. In the lowlands, Chinese cabbage, pak choi, capsicum, tomatoes, and cucumbers are sold, whereas in the highlands, cauliflower, lettuce, carrot, French beans and English potatoes are sold. In Port Moresby there are a few entrepreneurs who buy imported apples, oranges, potatoes and onions and resell them.

In Eastern Highlands Province, Bourke and Nema (1985) stated that betel nut is often sold in the Kainantu markets through entrepreneurs, and that "coconuts, mangoes and other lowland produce are sold in significant quantities", but this is done by growers who travel up from the lowland Markham Valley, rather than by highland wholesalers.
Future Trends

The markets have been established for two reasons:

(1) they provide producers with an area to conduct transactions with the public; and

(2) they provide urban people with a means of purchasing food.

Future trends should benefit both groups. In order to be successful the market must be able to do one or both of the following, either:

(a) convince the public that what it is offering is what the public requires; or

(b) anticipate what the public wants and attempt to provide it.

Market growth must also be able to keep pace with the increase in urban population. With the ‘soft sell’ approach adopted by vendors in the open markets, it is unlikely that the first option is ever going to be a significant factor.

For some years now, rice and tinned fish and meat have dominated the diet of urban dwellers. The high expectation of return from open market sales precludes the market producer/seller from being able to offer an economically viable substitute for these processed foods. Thus it appears that the second option is unlikely to have much evolutionary importance in ensuring the continuing success of the markets.

There is little doubt however that the markets will continue, but their effectiveness in supplying the burgeoning urban population with fresh food must be considered.

The majority of suppliers continue to be subsistence growers. Although recently the "commercial subsistence farmer" has emerged, the open market is unlikely to attract him for two reasons:

(1) the return on time invested is low, even with the high prices that are charged; and

(2) there is a barrier between commercial retail outlets and the sellers in the open market. Entrepreneurial retailing has never really become established, that is there are few sellers who are not growers, therefore there is little opportunity for the commercial producer to sell through market retailers.

Many market surveys have been undertaken, but research is seldom extended to the sellers’ properties or gardens, or to the problems that they may be encountering when they attempt to be efficient and cost effective producers and marketers of fruit and vegetables.
To date (1982) the government has concentrated on the organisation of a wholesale marketing system. This has not been successful in supplying the requirements of the urban market. Perhaps an alternative would be to examine the problems associated with the open market and attempt to resolve them.

Future efforts in this area could be oriented towards:

(1) organising cool storage in the markets to allow for the development of entrepreneurs and commercial subsistence farmers; and

(2) organisation of transport and handling systems which are geared towards these markets.

In conjunction with the above, attempts should be made to rationalise the production areas. There is little to be gained by encouraging growers in remote areas of Enga or Southern Highlands Provinces to produce vegetables for the Port Moresby market.

One aspect that should be given careful consideration in relation to production areas is the interest and natural propensity of the people to grow produce for sale. The adverse climatic conditions of Central Province create agronomic difficulties. This may have affected the attitude of the people towards food crop production, but it is probably true to say that the people of lowland Central Province have little interest in commercial gardening, even given the considerable incentive of a substantial urban market in Port Moresby.

THE WHOLESALERS

Recent Trends

Until its closure in mid-1981, the Food Marketing Corporation (FMC) was the only principal wholesaler interested in purchasing local fruit and vegetables. However the government decided that it was not proving to be a viable commercial proposition and thus its operation was closed down. During the latter part of 1981 the buying centres at Mt. Hagen, Goroka, and Kainantu were sold and used for other purposes by the purchasers. In 1982 the depots at Port Moresby and Lae were leased from the FMC by the Central and Morobe Provincial Governments respectively.

Concern about the closure of the FMC depot in Mt. Hagen stimulated the Western Highlands Provincial Government to form a buying organisation, the Central Highlands Food Marketing Corporation (CHFMC), which was subsequently put under the management of the Western Highlands Development Corporation and later closed down.

For wholesale marketing, the major change has been the breakdown in trading relations between the highlands and the major centres of Lae and Port Moresby. The wholesale markets are now not connected in any operational sense, and therefore are not obliged to trade with each other. In the last two years of its
operation, FMC transported to Lae vegetables purchased from its highlands depots. Since the decentralisation of the FMC, this function has been taken over in part by the CHFMC, and by farmers who own or hire transport.

The Lae market, now known as Niugini Produce Marketing, sells most of its vegetables locally, either wholesale or through its retail store. Some items, mainly lettuce, tomatoes, capsicum and cabbages, may be air-freighted to other wholesalers in Port Moresby, occasionally including its counterpart, Central Food Marketing (CFM).

From the outset of its operation, finding markets was a problem for the CHFMC. Some produce was sold in Lae and Madang, but the organisational problems of attempting to supply markets each with a few hundred kilograms of several different lines proved to be a managerial strain.

An attempt was made to set up an open market on Saturdays at Jackson's Airport in Port Moresby. The vegetables were transported from Goroka using an Air Niugini charter of an F27 aircraft. The scheme was poorly organised, and public interest waned after three weeks of chaotic selling. Steamships Pty. Ltd. subsequently undertook to run the charter and market the produce, provided that CHFMC supplied the vegetables. For CHFMC, this arrangement meant a regular market for three tonnes per week of fresh produce. Steamships however reported considerable losses in the first few months because of poor packing and handling.

Decentralisation of the marketing system has had its most profound effect on CFM in Port Moresby. Its primary function, to serve as a wholesale/retail market for the farmers of Central Province, with less emphasis on purchasing from the Highlands, has denied the market of an adequate and continuous supply of produce.

A prematurely expanded 'South Coast Food Project' administered by the Department of Primary Industry, and funded only by the National Public Expenditure Plan and not jointly with the European Economic Community as originally intended, has had to scale down its extension activities. As a result, the commercial production of introduced vegetables in Central Province is presently limited to three or four growers. Unless the extension services are revived, and the market is prepared to broaden its horizons, it is unlikely to resolve the financial problems it is experiencing. The supply problems experienced by CFM are compounded by a fairly competitive wholesale market in Port Moresby.

**Future Trends**

The future of the wholesale markets in Lae and Port Moresby is very uncertain considering their present mode of operation. In order to provide a useful service they must be able to offer a continuous supply of a wide range of fruit and vegetables. Without an extension service it has not been possible to achieve this.

Instead, they have become erratic suppliers whose high operational costs have made them rather expensive middlemen. The wholesaling of fruit and vegetables
in Papua New Guinea has come to mean the sale of imported and locally grown introduced vegetables and, to a lesser extent, staples to the hotels, some institutions and the supermarkets. The volumes moved through this system are relatively small and, with the fragmented nature of the operation, it is unlikely to ever be economically viable or particularly efficient. Port Moresby, Lae, Kieta and Rabaul accounted for 75 per cent of the total market for fresh produce. From a producer's point of view, the other centres represented such small volumes that it would be uneconomic to attempt to market there. Transport difficulties in getting produce to Kieta have so far rendered this market inaccessible.

There are eight wholesalers in Port Moresby competing for about 3000 tonnes of produce per annum, valued at about K1 million, sufficient perhaps to keep only one of them solvent, given the high overheads and high wastage that occur at present (1983).

For this method of supply to be viable, either the wholesalers must combine or the market must expand. There are four ways in which the market could expand, as listed below.

1. The reduction of imports is a method for increasing the sale of local produce. A recently introduced quota system, whereby wholesalers may import produce not exceeding the value of their local produce, may help in this regard. This can be seen as an attempt to both expand the market and ensure that wholesalers are more actively involved in promoting locally grown produce. However the effect may not be very significant. Although the total value of imported fresh fruit and vegetables may appear substantial, if the major lines (onions, potatoes, carrots, apples, pears, grapes, and oranges) are removed, the figure does not look quite so impressive. A total ban on tomatoes into Port Moresby would expand the market by 63 tonnes per year, which could be grown by another 20,000 plants, the equivalent of just over one hectare.

Of the major items, production of potatoes, carrots and oranges could be expanded to meet the requirements in Lae and Port Moresby, and perhaps the quota system will be inspirational in doing this. The market though is still not large. For example, Port Moresby imported in 1982 approximately 1500 tonnes of potatoes, which represents the harvest of about one hectare per week.

2. An alternative for expanding the market is import substitution, that is replacement of imported staples such as rice with a locally grown staple such as sweet potato. The convenience and low cost of rice make this an unlikely proposition.

3. The third possibility is the development of an export crop; bananas, pineapple and perhaps taro are possibilities.

4. A process industry would offer another mechanism for expanding the market, though it is unlikely that the present wholesalers would get involved in this.
Current policy does not favour expanding the market through any of the possibilities mentioned, apart from import reduction through the quota system.

Intending commercial producers of introduced vegetables should therefore consider the size of the market and its accessibility before they commence production.

DIRECT SELLING

Recent Trends

This form of selling is restricted to commercial producers and subsistence farmers whose operation has increased production to the point where selling through the open market is not possible.

For the less regular of these sellers, the price and the quantity to be purchased is usually set at the time of sale. Some of the more reliable producers have managed to secure what could loosely be described as a 'contract', an agreement to buy and sell, whereby the purchaser usually reserves the right to buy elsewhere in the advent of crop failure, adjust the price in times of glut, or turn to other suppliers if the quality deteriorates. Sellers in this category are characterised by their very rapid turnover.

The only large scale commercial producers who have been successful over the last five years are Kabiufa High School, Athol Green, Allele Pty. Ltd. and Ilimo farm. The last named has recently changed hands. The reason for their success is that these people and organisations have maintained a continuity of supply, and have had aggressive and persistent sales and marketing.

The advantages of the direct selling method of marketing, the ability to sell large volumes of produce, and perhaps the opportunity for a quick cash sale (usually to hotels, since institutions are often slow payers, particularly from the third quarter of the year onwards) are offset by the chaos which arises when more than one seller competes for a small number of buyers who have become very adept at manipulating these situations.

Direct selling was one of the contributing factors to the failure of the FMC, and probably the principal reason why all except four growers have failed.

Future Trends

The quota system is a policy which favours direct sellers. Since it was proposed at the beginning of 1983, wholesalers have made a considerable effort to contact growers, an effect it was designed to produce. However, so far it has been only the large producers who have benefitted by the scheme. Private enterprise vegetable retailers and wholesalers are accustomed to handling high quality, well packaged, imported produce in volume, and as yet have shown little interest in providing the infrastructure required to enable the small producer to benefit. The rather competitive nature of the private wholesalers has meant that there is little
communication between them. Market intelligence is essential if any order is to be established.

CONCLUSION

As the urban population grows, the problems of providing it with locally grown food also increase. The problems which fruit and vegetable growers face in attempting to market their produce continue to be a major constraint to the development of the industry.

There are two markets which must be catered for, the wholesale market as defined above, and the open markets. They have quite distinct and separate requirements.

A possible solution to wholesale marketing is to develop only one area in each major urban centre where commercial producers and buyers can conduct transactions. The market would not undertake to buy and resell, although an agent could sell on behalf of sellers from other parts of the country who wish to consign their produce to him. Market running costs could be covered by a commission.

The facilities of the open market need to be upgraded to meet increases in throughput. Improved washing facilities and cool storage would allow for the development of entrepreneurial sellers, an essential development if this market is to expand and become more efficient.

REFERENCES


COMMUNITY-BASED FOOD PROCESSING INDUSTRIES
FOR PAPUA NEW GUINEA: EXPERIENCES WITH THE
SITUM BANANA CHIP ENTERPRISE

Rashimah New

The Appropriate Technology Development Institute, Papua New Guinea
University of Technology, Lae, Morobe Province

ABSTRACT

The Appropriate Technology Development Institute (ATDI) has conducted research into community-based food processing operations. For the past two years it has been involved in the establishment of the Situm Banana Chip Enterprise. The project has progressed steadily and is now developing as a commercial venture. Their product known as "MR BANANA SIP", utilises surplus green bananas in a simple process involving peeling, slicing, drying, deep frying, salting and packaging. A model low cost processing kitchen has been established to suit village conditions and to meet health requirements. The people have developed their own style of business management to suit their social structure. The emphasis in this project has been to encourage a village-based commercial organisation to develop appropriate food processing technologies. The development of the project is being studied and documented in order to assess the potential for creating a viable community-based food processing sector. It is also hoped that the Situm facility can be used as an example for other community groups.

INTRODUCTION

There is a need to develop community-based food processing industries in Papua New Guinea (PNG). Attempts have been made by the government and institutions to promote self-reliance in various aspects of food processing technology. However most of the efforts have been on a large scale and have not involved people at the community level.

The development of food processing industries at the community level is an important aspect of achieving self-sufficiency in food production in Papua New Guinea. Research at the Appropriate Technology Development Institute (ATDI) has been carried out to meet the goals listed below.

1. To promote community-based food processing industries with emphasis on locally available raw materials.
2. Wherever practicable, to develop consumer foodstuffs as import substitutes.

3. To promote an improvement in food quality and nutritional value.

4. To develop and disseminate simple technology to suit the present stage of development in Papua New Guinea.

A model community-based food processing enterprise has been established in cooperation with the Situm Women's Group. Situm is a rural settlement about 20 kilometres outside Lae in Morobe Province.

The project has been strongly supported by the village people who have enthusiastically carried out the major portion of the ground work. It began about two years ago when Situm villagers started to build an addition to their trade store with the intention to develop a women's food making enterprise. They subsequently contacted A TDI staff members and were shown how to use their surplus bananas to make deep fried chips and to hygienically seal them in plastic bags for sale to the public.

The project received financial assistance from the International Human Assistance Programme, the Unitech Community Development Committee and the Foundation for the Peoples of the South Pacific. It has progressed steadily. Construction of the kitchen has been carried out through the voluntary labour of men in the village. The work has been of a high standard, reflecting the people's desire for a "professional" looking facility.

The women have become very proficient in deep frying and sealing techniques, and have achieved a product of uniform quality.

**PRODUCT DESCRIPTION**

The product, under the brand name "MR BANANA SIP", consists of lengthwise sliced, deep fried and salted banana chips, similar in taste, appearance and texture to potato chips. The chips are sealed in polyethylene bags with an enclosed printed label stating name, minimum weight of 35 grams and name and address of the producer. They are sold commercially through retail stores in Lae.

**SELECTION OF BANANAS**

Any type of banana can be used for the production of banana chips. Bananas used for this process must be harvested and processed in the mature green stage, prior to turning yellow. The use of immature green bananas results in chips which are less satisfactory in colour, texture and taste. Ripe bananas are not suitable because they are difficult to slice, take longer to dry and do not retain crispness.

For the Situm project, the variety known as 'Yava' is chosen because:

(1) it is the most readily obtainable, being available all year round;
it is easy to peel and less liable to change colour when cut; and

it is the least expensive.

'Yava' is a very common variety. Bourke (1976) described it as resistant to leaf spot disease, able to withstand drought, and tolerant of shade and nematodes. It bears well, even where the soil is poor.

Peeling is carried out by slitting the skins with a knife, and stripping them with the fingers. The sap of the skin sticks to and stains the hands. I recommended to the villagers that they coat their hands with cooking oil to minimise this problem. The villagers themselves found that rubbing salt on the hands is more effective.

The peeled bananas are dropped into a bucket of salted water which helps remove the remaining sap from the surface of the bananas. The waste skins are used for pig feed.

The peeled bananas are longitudinally cut into slices approximately 1.6 mm (1/16 inch) thick. This thickness is the same as that recommended by Adeva et al. (1968), Jain et al. (1962), and Bai and Rao (1969).

Initially, a locally made version of an imported slicer, consisting of a wooden board with a stainless steel blade, was used. However this proved to be inefficient and unhygienic. Now an imported moulded plastic unit with a stainless steel blade is used. This is quite reasonably priced and stocked by one of the major retail stores. The banana slices are dropped straight into salted water.

**Drying**

Drying is recommended as it helps to prevent the banana slices from sticking together when they are dropped into the frying oil. Undried slices take longer to fry and cause more rapid deterioration of the oil. Drying can be omitted as suggested by Jain et al. (1962) and Bai and Rao (1969), however Situm people once tried frying fresh banana slices and found that they were too difficult to handle. Banana slices are taken out of the salted water and placed on drying racks. These racks consist of plastic shade cloth stretched over light wooden frames. Earlier, flywire was used but it was difficult to clean, broke easily and corroded.

Drying racks are placed on shelves in the open shade. This makes it easier to control the drying process compared with drying in the sun. Drying is more uniform using this method. Only a small amount of drying is needed to remove the surface moisture. The women recognise when the slices are sufficiently dried. Over drying results in hard chips and poor colour.
DEEP FRYING

A high oil temperature (about 230° Celsius) is needed to get good quality crisp chips. An efficient smokeless firewood stove, made from a clay and sand mixture, has been constructed by the villagers with assistance from ATDI. The stove contains two aluminium washing bowls which are used as frying units. Banana slices are fried until they turn a golden brown. They are then drained, cooled and dusted with salt.

PACKAGING

Salted banana chips are packed into polyethylene bags and sealed with a hacksaw blade and candle flame. Initially the plastic bags were sealed with only a candle flame which, although functional, did not give a neat appearance. This method was then replaced by using a commercial plastic sealer powered by a car battery. This worked satisfactorily, but the villagers could not maintain the sealer themselves. When packed and sealed properly, banana chips stay fresh and crisp for up to 5-6 weeks.

The bags are then packed in second-hand cardboard boxes, sealed with tape and marked, showing the quantity and date produced.

TRANSPORTATION

Transportation is a major problem. Bananas have to be collected from distant food gardens. Situm villagers prefer to go to gardens and select the green bananas themselves, rather than have bananas delivered to them. Thus they can control the maturity of the bananas and the quantity purchased. They can also ensure a reasonable price. At present the banana bunches are carried in by hand, or a local minibus is hired for delivery. Chips are delivered to town by whatever form of transport happens to be available. Two solutions being considered are (1) the purchase of a second-hand two wheel tractor with trailer for carrying green bananas, firewood, and building and other materials; and (2) organising a regular delivery of banana chips to town with a local carrier. The idea of purchasing a utility vehicle is considered inappropriate because of the high initial cost, difficulties of maintenance, and the possibility of undisciplined usage.

PROCESSING UNIT

The low cost food processing kitchen constructed in the village is a simple wooden-framed building with screened windows and concrete floor. It includes a clay-sand stove, screened cupboard, open shelves, washing basin, first aid box and working tables. A ferro-cement water tank collects rain water from the roof for use in processing.
MARKETING

Initially, banana chips were sold informally through private orders and around the Situm area, at the local school and soccer field. At present an average of 700-1000 bags per week are marketed under the brand name "MR BANANA SIP" through two stores in Lae. Consumer acceptance has been good and it seems from reports from the store owners that the potential demand is far higher than 1000 bags per week.

MANAGEMENT AND ORGANISATION

The management of the enterprise follows a pattern of organisation which was largely set up by the villagers themselves, based on their experience in running their own trade store, piggery and cash cropping. The village headman is the ultimate decision maker. His wife is the chief organiser of the production operation. Their adopted son who runs the trade store looks after the bookkeeping and logistics. (It is interesting to note that none of these three receive any direct financial benefit. Profits from the enterprise go into the community account.) The Situm group has taken the first step towards formalising the business by opening a cheque account under the name "SIBASI" which stands for "SITUM BANANA SIP". This is an indication of their long term commitment to the project.

COMMERCIAL VIABILITY

When the project started, the economics of production were relatively simple. Bananas were obtained from the village gardens and nearby villages. Oil, salt, plastic bags and other items were purchased in small quantities from trade store wholesale suppliers. Labour was mostly on a voluntary basis. As the project became more commercialised, it became clear that it was necessary to determine a buying price for bananas, and to purchase in bulk oil and salt, to cut down material costs.

Labelling became necessary to meet Department of Labour and Industry regulations, thus increasing the packaging cost. A scale of wages was introduced to pay the staff. Arrangements have also been made for the transport of raw materials and finished products. These steps have ensured more regular production to meet the growing demand from urban sales outlets.

This process of development from a village pilot project to a more commercially oriented enterprise is continuing step by step. Some of the cost factors are now being assessed and calculated in a conventional business-like manner, whereas other aspects of the costing are still affected by the village perception of customary rights and responsibilities.

At present it is difficult to say whether the enterprise is viable within the normal commercial meaning of the term. What is clear is that income is greater than expenditure, the women working in the enterprise are paid a satisfactory wage, the village economy is benefiting, and the people are proud of their achievement.
In the long term, it seems that this enterprise could grow to become a significant local producer of snack food products. Nevertheless, if the enterprise is to retain its true village-base character, this development will be slow, as the villagers themselves gain the necessary expertise.

**FOOD HYGIENE AND SANITATION**

Both personal and food hygiene, along with sanitary working practices are vital to any food processing operation. Lack of care leads to contamination which could endanger the public. In setting up the Situm community-based food processing enterprise, efforts have been made to guarantee the hygienic quality of the products. Deep frying sterilises the dried banana slices. Thus the most vulnerable part of the process where contamination could occur is in the latter steps of salting and packaging. The women are required to wash their hands with soap before handling the chips.

The sanitary education programme introduced at Situm is detailed below.

1. The people have been informed of the requirements of the Health Department of the Lae Interim Authority. A poster is used as a reminder.

2. Arrangements were made for all the people involved to visit other local food processing factories, such as Morobean Biscuits Co. Ltd. and Lae Biscuits, so they could see for themselves the standards of hygiene that must be maintained.

3. A hand-washing basin with soap is provided in the processing kitchen.

4. A foot-washing facility will be built at the entrance to the processing kitchen, since the villagers never wear footwear.

5. Aprons have been supplied to all staff and are washed regularly.

In general the hygiene arrangements are satisfactory. The people are keeping themselves and the working area clean. The sanitary education of the Situm people is not any different from other aspects of the project. The approach is straightforward but gradual to let them absorb the process of change rather than forcing them to follow a rigid set of instructions.

**NUTRITIONAL ANALYSIS**

The following preliminary analysis of the banana chip product has been carried out by the joint DPI-Chemical Technology Food Processing Unit of the Papua New Guinea University of Technology. For comparison, an analysis of unflavoured potato chips is included (Table 1).

It should be noted that as there is no precise means of controlling the frying temperature in the chip making process, it is expected that the amount of fat
absorbed during frying will vary, and thus affect the proximate composition. It is still necessary to analyse a larger number of samples to obtain a valid mean and range for each component.

Table 1. Nutritional value of banana chips and potato chips.

<table>
<thead>
<tr>
<th>Component</th>
<th>Banana chips</th>
<th>Potato chips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (per cent)</td>
<td>4.21</td>
<td>2.70</td>
</tr>
<tr>
<td>Fat (per cent)</td>
<td>23.1</td>
<td>32.6</td>
</tr>
<tr>
<td>Protein (per cent)</td>
<td>1.75</td>
<td>6.90</td>
</tr>
<tr>
<td>Ash</td>
<td>1.95</td>
<td>3.90</td>
</tr>
<tr>
<td>Carbohydrate, by difference (per cent)</td>
<td>68.9</td>
<td>54.1</td>
</tr>
<tr>
<td>Energy (Kj/100 g)</td>
<td>1930</td>
<td>2128</td>
</tr>
</tbody>
</table>

DISCUSSION

The experience with Situm people has led me to realise that their business practices, which may seem unconventional, are logical in terms of their own perceptions and social structure. The group is highly motivated, socially coherent and very much committed to their own community. Community obligations are usually given priority over business activities. Nevertheless, they have been able to take a flexible approach to integrating production with their village life. Areas that I thought would be a problem such as non-cash incentives or payment of minimum wages, were gradually solved in an informal Melanesian way. Outside assistance has been minimised, and the people seem to be able to handle most difficulties independently. The main need now is to increase production to meet the demand and achieve a more commercially viable scale of operations.

The Situm group has taken the initiative to teach what they have learned to interested neighbours, community groups or school children and have participated in a number of ATDI workshops. They recently accommodated a group of people from a Sepik Women’s Club and gave them a thorough on-the-job training for three weeks. They are proud to show off their accomplishment and have not considered the problem of creating competition. In any case there appears to be more room in the market for quality snack food products.
CONCLUSION

The progress of the Situm Project so far indicates that (1) it is possible to carry out community based food processing using simple production systems and technologies; and (2) it is necessary to evolve a style of production and management which will satisfy both the requirements of commercial viability and the realities of the village condition.

The Situm Project is being thoroughly studied and documented for use as a possible model for other village food processing enterprises. My experience with Situm people has indicated certain features in project management that might be instructive to those who work in similar fields. That is, the approach must be slow but steady to allow time for the villagers to solve their own problems in their own way. They should be encouraged to make their own decisions and to contribute their ideas, skills, time and finance towards the project. Development workers should be confident to advise and take a leading role when required but also be prepared to step back when necessary.

REFERENCES


A STUDY OF MARKETING COSTS AND MARGINS OF MEAT IN LAE

D.K. Das

Department of Agriculture, Papua New Guinea University of Technology, Lae, Papua New Guinea

ABSTRACT

A study was undertaken with a view to estimating costs and margins in beef marketing in Lae. The nature of costs and margins in different stages of the marketing channel indicated that the producer received only 47.1 per cent of the consumer price, whereas the marketing margin constituted 52.9 per cent. The profit at the wholesale level was found to be modest and reasonable, whereas at the retail level the profit margin was almost 30 per cent of the consumer price. Over a period of four years from 1979 to 1983, the marketing costs and margins increased from 43 per cent of the consumer price in 1979 to 53 per cent in 1983, thereby reducing the marketing efficiency.

INTRODUCTION

An efficient marketing system encourages farmers by giving them fair returns for their produce and thereby providing a service as one of the key components for increasing agricultural productivity. The efficiency of a market is generally measured in terms of 'net marketing margins' (net marketing margins = total marketing margins - all marketing costs) of an agricultural commodity. The smaller the net marketing margin the greater the efficiency in the marketing system and vice versa. Marketing costs and margins refer to the difference between the price paid by the consumer and the price received by the producer for an equivalent quantity of a product.

The objective of an analysis of marketing costs and margins should be not only to look for a reduction in costs, but also to ensure that necessary services required in the marketing process are provided efficiently from the point of view of both producers and consumers. In some cases improvements in the marketing system, such as provision of additional marketing services, may increase the costs of marketing. If consumers value these services more than the corresponding savings in cost, it represents an increase in efficiency. Improving the standard of service with the same or lower costs, or reducing the cost for performing the same marketing functions for the same job, clearly represents an increase in marketing efficiency.
It is often believed that beef prices in retail markets are generally high. As the prices are largely made up of marketing costs and margins, the present study was undertaken with a view to estimating these costs, margins and price spread in beef marketing in Lae. The exact nature of costs and margins involved in different stages of the marketing channel are distinguished and evaluated, thereby enabling us to suggest ways and means to reduce the price spread for the benefit of both producers and consumers.

OBJECTIVES OF THE STUDY

The specific objectives of the study were:

1. to determine the magnitude and composition of marketing costs and margins for beef;
2. to compare the marketing costs and margins over a period of time;
3. to identify the problems in marketing activities; and
4. to suggest alternative arrangements which may improve the performance of the marketing system.

METHODOLOGY

In this study, "gross margins" were calculated by comparing prices at successive levels of marketing at a given time. The "net margins" or "profit margins" of the intermediaries were calculated by deducting the ascertainable costs from the gross margin at different stages of marketing.

The terms "costs" and "margins" were defined as follows:

Costs: the costs incurred for providing the marketing services such as handling, transport, storing, packing, grading etc., assuming that all costs, including amortisation are taken into account.

Net Margins: the additional value a dealer charges to a customer on top of the price paid plus identified direct marketing costs incurred, to cover his own labour, return on capital and risk.

The study was conducted in Lae town. Lae market was selected for the study because Lae is one of the main consuming centres and a central abattoir is located there. The data on costs and margins were collected from Lae abattoir, wholesale agents and retailers in May and June, 1983. To observe the trends in marketing costs and margins, studies were carried out in 1979 and 1983.
EXISTING MARKETING SYSTEM FOR CATTLE AND BEEF

Cattle are raised on large ranches as well as on smallholder cattle farms. Large ranches generally sell their cattle by private treaty to cattle marketing agents, usually on delivery to a central slaughter facility. Smallholders sell their cattle either to wholesalers through the help of the Division of Primary Services under the Provincial Government, or to cattle marketing agents. At present, since there is no alternative marketing system, the Division of Primary Services is required to play an important role in marketing smallholder cattle. The Division advises on the sale of cattle and arranges transport to the slaughter house, though the cost of transport is borne by the farmers.

The typical cattle marketing channels are shown in Figure 1. Wholesalers place their demand for cattle with extension officers who in turn contact smallholders and arrange for the supply of cattle to the abattoir for slaughtering.

Figure 1. Typical cattle marketing channels.
The selling of cattle is done on the basis of private arrangements made between the field extension officer, slaughter house manager and stock agents. Growers receive payment for cattle sold to wholesalers or stock agents on the basis of carcass weight. The prices are determined by informal mutual agreement between retailers and the industry, represented by bodies such as the New Guinea Graziers Association, the Morobe Farmers Association and the Division of Primary Services.

MARKETING COSTS AND MARGINS OF BEEF

After cattle are slaughtered at an abattoir they are received by the wholesaler and sold to retailers. The carcasses are cut and debored by retailers and sold to consumers.

The gross marketing costs and margins for cattle/beef produced in areas around Mumeng and marketed in Lae are given in Table 1. The producers received 47.1 per cent of the price paid by consumers in Lae. The gross marketing margin amounted to K332.54 which is 52.9 per cent of the consumer price.

MARGINS OF THE WHOLESALER AND RETAILER

The wholesaler’s margin which included slaughtering, transport and handling charges was 8.6 per cent of the consumer price. The costs relating to marketing functions constituted 5.4 per cent and the net wholesale margin accounted for 3.2 per cent of the consumer price.

The data show low gross margins at the assembly and wholesale levels. This is mainly due to the fact that extension officers help farmers to organise and carry out the marketing of cattle from the farm to the abattoir. As such the farmers calculate for this assembly function a very low or zero opportunity cost. Besides, due to large turnover of carcass numbers at the wholesale level, wholesalers keep a low margin per head of cattle. As they operate on a large scale, they can realise a substantial total profit, although taking a low profit per unit weight of commodity. This low margin keeps the price down and thereby ensures a steady demand for beef from retailers.

At the retail level, the costs and margins were 44.3 per cent, of which costs for physical marketing function accounted for 14.1 per cent, costs due to loss in weight accounted for 0.7 per cent, and the profit margin accounted for 29.5 per cent of the consumer price.

Estimates of retail sale prices and margins have been made on the basis of the values of various cuts of beef (Appendix 1). The retail gross margin was found to be as high as K278 for a carcass weight of 250 kg, which means a mark-up of 79 per cent on the purchase price that retailers pay. This high margin is due to skilled cutting, refrigeration and other services.
Retailers (in this case supermarkets) with a high proportion of joint and fixed costs (all the retail butchers in Lae fall in this category) may apply a uniform mark-up to their buying prices in order to fix a selling price for each commodity. This may be a common practice in the supermarkets catering for wealthy families buying refrigerated goods and imported products. The high retail gross margins can be explained by the fact that retailing to high income consumers also means higher retail costs. Since labour and living costs are high in Papua New Guinea it is likely that retailers use a high margin.

Table 1. Marketing costs and margins of beef (250 kg carcass) (origin: Mumeng; terminal market: Lae).

<table>
<thead>
<tr>
<th>Marketing component</th>
<th>Cost (Kina)</th>
<th>Share of consumer price (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm gate price (net to producer)</td>
<td>295.50</td>
<td>47.1</td>
</tr>
<tr>
<td>+ transport to slaughter house, Lae from Mumeng (76 km)</td>
<td>17.00</td>
<td>2.7</td>
</tr>
<tr>
<td>+ slaughtering charge</td>
<td>16.00</td>
<td>2.5</td>
</tr>
<tr>
<td>+ transport from abattoir to wholesale factory, and handling charges</td>
<td>1.10</td>
<td>0.2</td>
</tr>
<tr>
<td>+ profit margin of wholesaler</td>
<td>20.40</td>
<td>3.2</td>
</tr>
<tr>
<td>Meat wholesaler's selling price to retailers</td>
<td>350.00</td>
<td>55.7</td>
</tr>
<tr>
<td>+ storage at retail shop</td>
<td>52.50</td>
<td>8.4</td>
</tr>
<tr>
<td>+ packaging</td>
<td>10.34</td>
<td>1.6</td>
</tr>
<tr>
<td>+ loss in weight</td>
<td>4.55</td>
<td>0.7</td>
</tr>
<tr>
<td>+ other, including labour costs</td>
<td>25.54</td>
<td>4.1</td>
</tr>
<tr>
<td>Retailer's profit margin</td>
<td>185.11</td>
<td>29.5</td>
</tr>
<tr>
<td>Retail butcher's selling price to consumer</td>
<td>628.04</td>
<td>100.0</td>
</tr>
</tbody>
</table>

1Live animals are transported from the farm to the abattoir. The producer receives payment on the basis of carcass weight. At present (1983) the steer/heifer rate is K1.25 per kg of carcass weight, paid by wholesalers.
MAIN COST ITEMS IN MARKETING BEEF

The major cost items in the marketing of beef together with their percentage shares of the consumer price are given in Table 2.

The marketing costs constitute 20.2 per cent of the consumer price. A break-up of the cost components indicates that the cost of storage is approximately 41 per cent of the total marketing cost (K52.50 out of K127.03). The next highest component is labour costs (K25.54 which is 20 per cent of marketing costs) followed by transport costs (K18.10 which is 14 per cent of the marketing costs).

SLAUGHTERING

The slaughtering of animals results in the production of carcasses and by-products (i.e. hides, and other edible and non-edible by-products). An important factor in assessing costs and margins is to assess accurately the value of the carcass and the by-products.

An analysis of the income and expenditure of the Lae slaughter-house was carried out with a view to finding out whether the slaughter fees and other income from by-products (such as meat meal, tallow etc. which belong to the slaughter house) cover the operating and capital costs of the abattoir.

Income and expenditure figures for the Lae abattoir for 1981 are given in Table 3. These showed an operating loss of K25,826. Adding depreciation of K36,738 for capital assets, the net loss was K62,564.

On the basis of this data the operating cost per unit of cattle1 was K25.61; and, including depreciation of capital assets, the total cost incurred per unit of cattle was K30.69.

The income per unit of cattle was calculated to be K22.04. This demonstrates that the slaughtering fees do not cover the cost of running the abattoir, and the government is subsidising the beef industry.

It appears that the slaughter house has high costs, partly because supplies have proved inadequate to keep it fully employed. The potential economies of scale which could be obtained from the plant have not been realised. Around 7,000 cattle are slaughtered yearly whereas the capacity of the slaughter house is 20,000 per year.

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1The number of pigs, sheep and goats slaughtered in the abattoir were converted into cattle units to determine the operating cost per cattle. The conversion rate is 5.33 pigs, sheep or goats is equivalent to 1 cattle. This ratio was calculated on the basis of the slaughtering fees for different animals.
Table 2. Main cost items in the marketing of beef (carcass weight 250 kg).

<table>
<thead>
<tr>
<th>Item</th>
<th>Costs and margins (Kina)</th>
<th>Per cent of consumer price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total gross margin</td>
<td>332.54</td>
<td>52.9</td>
</tr>
<tr>
<td>Components:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport</td>
<td>18.10</td>
<td>2.9</td>
</tr>
<tr>
<td>Slaughter cost</td>
<td>16.00</td>
<td>2.5</td>
</tr>
<tr>
<td>Storing</td>
<td>52.50</td>
<td>8.4</td>
</tr>
<tr>
<td>Packaging</td>
<td>10.34</td>
<td>1.6</td>
</tr>
<tr>
<td>Losses in weight</td>
<td>4.55</td>
<td>0.7</td>
</tr>
<tr>
<td>Others, including labour costs</td>
<td>25.54</td>
<td>4.1</td>
</tr>
<tr>
<td>Sub-total of all marketing costs</td>
<td>127.03</td>
<td>20.2</td>
</tr>
<tr>
<td>Net margin</td>
<td>205.51</td>
<td>32.7</td>
</tr>
</tbody>
</table>

Note: it is difficult to ascertain the costs for physical marketing functions (such as storage, labour costs etc.) of one commodity at the wholesale and retail levels. This is because the wholesalers and retailers deal with more than one product, and cost items are shared amongst various products handled. Thus best estimates of costs have been made by taking into consideration the proportion of beef in the total product handled.

Table 3. Income and expenditure of Lae Abattoir in 1981.

<table>
<thead>
<tr>
<th>Income/expenditure</th>
<th>Kina</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total operating costs</td>
<td>185,150</td>
</tr>
<tr>
<td>Total income</td>
<td>159,324</td>
</tr>
<tr>
<td>Operating profit (loss)</td>
<td>(25,826)</td>
</tr>
<tr>
<td>Depreciation of capital assets</td>
<td>36,738</td>
</tr>
<tr>
<td>Net profit (loss)</td>
<td>62,564</td>
</tr>
</tbody>
</table>
BY-PRODUCTS

Edible offal belongs to the butcher, and is sold to consumers. Inedible offal belongs to the abattoir. Its value has been taken into account in calculating the income of the abattoir. Hides belong to the wholesaler and their value has been taken into account while calculating costs at the wholesale level. At present (1983), the hide price is K1.00 per piece.

LOSSES IN WEIGHT

Since payment is made on the basis of carcass weight, the amount of loss during transport of live animals has not been considered. In storage, losses in weight occur due to tissue shrinkage and this has been accounted for.

TRENDS IN PRICE SPREAD

To examine changes in the efficiency of the beef marketing system over time, the marketing costs and margins for the years 1979 and 1983 were compared, and these are presented in Table 4.

It may be seen from Table 4 that the net share to the producer has decreased from 56.7 per cent of the consumer price in 1979 to 47.1 per cent in 1983. The gross margins (i.e. the marketing costs and margins of the intermediaries) which totalled K152.38 in 1979 have increased to K332.54 in 1983. These accounted for 43.3 per cent of the consumer price in 1979 and 52.9 per cent in 1982.

The percentage marketing margin \((P_R - P_F)/P_F \times 100\), where \(P_F\) is the farm gate price and \(P_R\) is the retail selling price) has increased from 76.3 per cent in 1979 to 112.5 per cent in 1983. Thus it may be said that the marketing efficiency of the beef industry has decreased considerably during these four years.

The efficiency has decreased mainly due to higher mark-up percentages claimed by the intermediaries (wholesaler as well as retailers). For example, the mark-up percentage over purchase price for the wholesaler has increased from 8.9 per cent in 1979 to 18.4 per cent in 1983.

Similarly, for retailers the mark-up percentage on their cost price has increased from 61.9 per cent in 1979 to 79.4 per cent in 1983. Net margins have also increased for both wholesalers and retailers. As proportions of the consumer price, net margins have increased from 2.4 per cent in 1979 to 3.2 per cent in 1983 for wholesalers, and from 20.4 per cent in 1979 to 29.5 per cent in 1983 for retailers. The total net margins of the intermediaries have been increased from 22.8 per cent of the consumer price in 1979 to 32.7 per cent in 1983. Also, the operational costs of various physical functions have been increased. For example the cost of transportation which was about 1.9 per cent of the consumer price in 1979 has increased to 2.9 per cent in 1983. Similarly, the slaughter charges have increased
from 0.8 per cent of the consumer price in 1979 to 2.5 per cent in 1983.

These results indicate that the same functions, without any change in the quality of services, are now performed with higher costs, which is a clear case of decreased marketing efficiency. The high margins should be reduced, to improve the marketing efficiency, by providing a more remunerative price to the grower and charging a fair price to the consumer.

Table 4. A comparison of marketing costs and margins of beef in 1979 and 1983 (carcass weight = 250 kg).

<table>
<thead>
<tr>
<th>Price/cost</th>
<th>1979</th>
<th>1983</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cost (Kina)</td>
<td>Share of consumer price (%)</td>
</tr>
<tr>
<td>Farm gate price (P_f)</td>
<td>199.74</td>
<td>56.7</td>
</tr>
<tr>
<td>+ transport to abbatoir (borne by farmer)</td>
<td>5.50</td>
<td>1.6</td>
</tr>
<tr>
<td>+ slaughter fees (borne by wholesaler)</td>
<td>3.00</td>
<td>0.8</td>
</tr>
<tr>
<td>+ profit margin of wholesaler</td>
<td>8.29</td>
<td>2.4</td>
</tr>
<tr>
<td>Wholesalers' selling price to retailers</td>
<td>217.50</td>
<td></td>
</tr>
<tr>
<td>+ storage</td>
<td>37.50</td>
<td>10.6</td>
</tr>
<tr>
<td>+ packaging</td>
<td>7.39</td>
<td>2.1</td>
</tr>
<tr>
<td>+ loss in weight</td>
<td>2.83</td>
<td>0.8</td>
</tr>
<tr>
<td>+ other</td>
<td>14.95</td>
<td>4.2</td>
</tr>
<tr>
<td>+ retailers' net margin</td>
<td>71.95</td>
<td>20.4</td>
</tr>
<tr>
<td>Meat retailers' selling price to consumer (P_r)</td>
<td>352.12</td>
<td>100.0</td>
</tr>
<tr>
<td>Price spread [= price at retail outlet - price at farm]</td>
<td>152.38</td>
<td>43.3</td>
</tr>
<tr>
<td>Net margin of all intermediaries</td>
<td>80.24</td>
<td>22.8</td>
</tr>
<tr>
<td>Percentage marketing margin [= (P_r - P_f)/P_fx100]</td>
<td>76.3 %</td>
<td></td>
</tr>
</tbody>
</table>
SUMMARY AND CONCLUSIONS

The results of the study indicated the following conclusions:

1. The gross marketing margin for beef was 52.9 per cent of the consumer price.

2. The producer received only 47.1 per cent of the consumer price.

3. The wholesaler's gross margin was 8.6 per cent, of which the net margin was 3.2 per cent of the consumer price. The profit as a percentage of the wholesaler's purchase price was not more than 7 per cent. The profit level appeared to be very modest and reasonable.

4. The retailer's gross margin was 44.3 per cent of which the net margin was 29.5 per cent of the consumer price. The profit, as a percentage of the retailer's purchase price, was 52.9 per cent. The retailer's profit level appeared to be high, though the services provided are of a high standard.

5. Over a period of four years, the marketing costs and margins have been increased from 43.3 per cent of the consumer price in 1979 to 52.9 per cent in 1983, thereby reducing the marketing efficiency. Inefficiency has increased due to increases in various marketing costs and higher net margins of the intermediaries.

The present study points out two major areas which need consideration. These are transportation costs and high net margins at the retail level. Thus the main possibilities for reducing marketing costs and margins are improvement in the transportation system and enforcement of retail price control.

Transport charges increase with the distance travelled, and the higher the cost of transport, the greater is the reduction in the producer's revenue. There are also problems in assembling cattle from smallholder projects in remote areas.

Possibilities for reducing the transport cost and overcoming assembling problems include:

1. Forming farmers' cooperative associations, or developing a marketing board which will undertake rationalisation of the transportation of cattle to the abattoir. Better management and planning could provide significant savings in this area.

2. Establishing rural slaughter facilities in producing centres, thereby reducing the problems of assembling and transportation of live cattle over long distances.

3. Developing the role of cattle marketing agents who would purchase cattle and rationalise transport.
Price differences between successive stages of marketing should reflect all costs the middleman incurs plus a normal profit margin. If the profit margin at retail level is judged to be much higher than normal profit, price control regulation may be considered for protection of the consumer. A pricing policy should also be aimed at stabilising the prices of meat so that growers are assured of a stable price.

On the demand side, the size of the population and the per capita income of the consuming population are important factors affecting the price spread. On the other hand the supply schedule, which is determined by production, is inversely related to the retail-farm price spread. Therefore, the magnitude and direction of these factors must be considered when formulating a sound pricing policy that will benefit both growers and consumers.
APPENDIX 1

Value of cut beef (carcass weight = 250 kg) in a retail butcher shop in Lae, 1983.

<table>
<thead>
<tr>
<th>Details of cut</th>
<th>Weight (kg)</th>
<th>Ratio cut to total body weight (%)</th>
<th>Retail price (Kina/kg)</th>
<th>Value (Kina)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fillet</td>
<td>1.900</td>
<td>0.76</td>
<td>6.99</td>
<td>13.28</td>
</tr>
<tr>
<td>Rump</td>
<td>9.750</td>
<td>3.90</td>
<td>4.96</td>
<td>48.36</td>
</tr>
<tr>
<td>T-bone</td>
<td>16.150</td>
<td>6.46</td>
<td>3.98</td>
<td>64.28</td>
</tr>
<tr>
<td>Top side</td>
<td>14.800</td>
<td>5.92</td>
<td>3.72</td>
<td>55.06</td>
</tr>
<tr>
<td>Round</td>
<td>9.500</td>
<td>3.80</td>
<td>3.62</td>
<td>34.39</td>
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<tr>
<td>Chuck</td>
<td>9.700</td>
<td>3.88</td>
<td>3.84</td>
<td>37.25</td>
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<tr>
<td>Blade</td>
<td>18.075</td>
<td>7.23</td>
<td>3.44</td>
<td>64.17</td>
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<tr>
<td>Silver side</td>
<td>13.350</td>
<td>5.34</td>
<td>3.60</td>
<td>48.06</td>
</tr>
<tr>
<td>Rolled rib roast</td>
<td>17.800</td>
<td>7.12</td>
<td>3.99</td>
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<tr>
<td>Brisket</td>
<td>10.625</td>
<td>4.25</td>
<td>2.99</td>
<td>31.77</td>
</tr>
<tr>
<td>Skin</td>
<td>12.825</td>
<td>5.13</td>
<td>3.35</td>
<td>42.96</td>
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<tr>
<td>Topskirt</td>
<td>1.650</td>
<td>0.66</td>
<td>3.72</td>
<td>6.05</td>
</tr>
<tr>
<td>Kidney</td>
<td>0.725</td>
<td>0.29</td>
<td>3.40</td>
<td>2.54</td>
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<tr>
<td>Mince</td>
<td>87.550</td>
<td>15.02</td>
<td>2.90</td>
<td>108.90</td>
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<tr>
<td><strong>Total edible meat</strong></td>
<td><strong>174.400</strong></td>
<td><strong>69.76</strong></td>
<td><strong>628.04</strong></td>
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</tr>
<tr>
<td>Bone</td>
<td>45.475</td>
<td></td>
<td>18.19</td>
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<tr>
<td>Fat</td>
<td>26.875</td>
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<td>10.75</td>
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<td>Loss</td>
<td>3.250</td>
<td></td>
<td>1.30</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>250.000</strong></td>
<td></td>
<td><strong>100.00</strong></td>
<td></td>
</tr>
</tbody>
</table>
SAGO: A NEW PERSPECTIVE

Lucy Sow

East Sepik Women's Association, Wewak, East Sepik Province

ABSTRACT

The general manual method of sago extraction and preparation is outlined. Some advantages and disadvantages of the use of sago as the main staple food are discussed.

INTRODUCTION

1. Sago is a major staple food in the East and West Sepik, Gulf and Western Provinces of Papua New Guinea (PNG). Also, in many other provinces sago has constituted a traditional supplement to root crops in times of famine, poor harvest or while new food gardens are being established. In many of these places sago is now assuming a more important role, as the quantity of subsistence garden production declines.

2. Where sago grows in natural abundance, it is often taken for granted by development planners. There is a commonly held (if not expressed) opinion that sago-dependent people are backward and primitive.

3. Cultivation and management of sago stands by villagers is also often taken for granted or poorly understood.

4. Sago-dependent communities make fine distinctions between apparently different cultivars, and their value as food or for other subsistence purposes.

5. Sago makers can list many differentiating features of different sago varieties.

6. Associated with the post-harvest handling of sago is a complex traditional technology unparalleled by the traditional systems of root crop harvests and storage. Sago starch extraction requires the construction of elaborate washing troughs and collection vessels.

7. Throughout the main sago using areas, the basic steps in the process of sago starch extraction are the same. They include chipping the starchy pith of felled and split sago palm trunks....

8. .... followed by further refinement on pulverisation.
9. The fibrous pith containing the starch is then washed in an elevated trough, and ....

10. .... the starch suspension strained out into a collecting vessel below.

11. The fibre is washed until the water runs clear. The waste fibre is then discarded and replaced by a new load, and so on. This is long tedious work almost always carried out by females.

12. As a staple food, sago has some advantages. It can be stored as unprocessed trunk lengths in water, and ....

13. .... when processed as wet starch it may be stored in clay pots in the household for a further 3-4 months.

14. Once stored as wet starch, sago provides the basic ingredient for some quickly and easily prepared meals, e.g. making pancakes from pure starch, or preparing a gel from sago and boiling water, the two most common meals in East Sepik households.

15. Similarly, simple all-starch preparations with this sago ball can be made anywhere, with only a fireplace required.

16. Sago is often criticised for its complete lack of vitamin content. Sago grows in swampy, often marginal land, and often vegetable and/or protein accompaniments are just not available.

17. The widespread use of pure sago in very early infancy and weaning preparations is also an issue of concern for nutritionists.

18. Ironically where sago is less important in daily subsistence, one finds many varied and nutritious recipes. Some of these use the same basic ingredients, but in preparations which produce a very different product in texture and taste.

19. Many of these recipes found in Manus, Oro and Madang Provinces allow for the addition or inclusion of many different kinds of vegetables, nuts and fish or meat. They are good ideas for nutrition educators to adapt to areas where the patterns of sago consumption are based on less nutritious recipes, and where there is evidence of high rates of malnutrition.

20. 'Saksak emi bun bilong Sepik.' ['Sago is the strength of the Sepik', eds.] It is also a much loved and vital staple food in many parts of Papua New Guinea. The nature and extent of apparently vast supplies of sago is not fully known. Proposals have been made to mechanically exploit starch for ethanol fuel production. However the current research on sago as a staple food and snack food ingredient is more urgent. It is also more likely to bring some form of agriculture and nutrition development to the people living in marginal swamps, where many have professed that no development programme could take place.
The future Simbu, Milne Bay, West Sepik (Sandaun) and Manus projects appear to be giving more attention to provincial government aspirations, with a greater prospect of the incorporation of the planning process into the provincial government operations, rather than as an alien transplant upon the province. The more slowly evolving design might provide a result more suited to the provincial government planning capacity. The Milne Bay and West Sepik projects also include large-scale resource projects.

The distribution pattern of potential benefits to those who could gain from improved public policies, and agricultural technology training, is as yet undemonstrated and will depend upon access to, and attractiveness to, the majority. Given the Papua New Guinea circumstances and the evidence of the ESRDP and SHRDP (unpublished data) there is no guarantee that benefits will not be concentrated among the few who are able to take advantage of the new infrastructure and improved public services. Modifications in the case of the later projects may assist the efficiency of investment and public services, but benefits could be to minimal numbers due to the above difficulties.

**ABANDONMENT OF IRD**

The outright rejection of IRD, for all applications (Heyer et al. 1981) is proposed on two grounds: that of its inefficiency, and that it cloaks a covert form of imperialism, exerting control over the rural population, extracting a disproportionate share for international finance and agribusiness. To reject IRD outright, on these grounds, means either that there are superior alternatives to IRD for all applications, or that all versions of IRD are so undesirable that nothing is preferable to any form of IRD.

What appear to be at issue are the following:

1. the limits to the effectiveness of externally introduced, autonomous authorities;
2. the difficulty in understanding the technical and social problems;
3. the degree of expenditure that the planning-administrative capacity can handle effectively;
4. the high costs of resettlement and infrastructure per attractive job;
5. the difficulty of substantial reorganisation without adverse effects; and
6. the prospects for transferring resources and income opportunity to disadvantaged, less influential groups through a planning process.

Several alternatives to fully-fledged IRD have been suggested. These are:

(a) allocation of the IRD funds to existing public institutions or their reformed versions (Shaw 1980);
(b) informal nucleus estates as a means to lift production, productivity and incomes (Young 1983);

(c) introduction of infrastructure and technology that is attractive to the smallholder and does not involve his reorganisation (Etherington and Carrad 1983) and;

(d) large-scale resource projects which quickly establish production, utilise unused resources, and sometimes bring some of their own finance (Manning 1983).

None of these options would be superior to IRD except where finance, skills and services were in competition. In some form, all these proposals exist in current or proposed IRD projects, but the above alternatives imply that a coordinated and comprehensive approach is not required. All proposals appear to need certain conditions if they are to have more than a marginal effect.

Investment in the existing institutions is more an argument against new autonomous authorities than against the coordination of public services. It does not exclude an integrated approach. In the view of some (Manning 1983), investment in existing public institutions is not a viable option in some areas. Renovations to public institutions (Young 1983) may certainly improve the morale and some efficiency, but there is not as yet compelling evidence that this will do more than cater to a marginally larger clientele. Clearly these approaches need special conditions (public services are the one missing factor) if they are to have a substantial effect on living standards.

Informal nucleus groupings (Young 1983), by definition, are likely to apply less to less developed areas, since all necessary conditions for higher living standards, except the suggested credit, training and technology would need to be present. So too would the plantation support.

The provision of infrastructure and technology that is attractive to smallholders (Etherington and Carrad 1983) is not necessarily an argument against the more recent forms of IRD in Papua New Guinea, but more one against the plantation or large scale mode, and it is an emphasis on productivity and foreign exchange. In some respects the ESRDP Intensification Sub-project is of this approach. Those without suitable land are excluded. Change may involve little more than staking out ground with never-to-be-maintained tree crops. It remains to be shown that food crops will be a major solution to complex problems. The issue is rather one of the technology mix, and the necessity of overheads.

Large scale resource projects have been included in two projects. They generally provide few jobs per unit of capital, reducing even this to wage labour status, and return limited government revenue and foreign exchange contributions. Also if they involve resource they are limited to resource rich areas.
CONCLUSIONS

1. IRD has generally a poor performance record, indicating that large doses of capital, and a passing deference to social change do not necessarily result in improved living standards for all. Nevertheless, the later Papua New Guinea versions of IRD indicate a potential role in obtaining gap-filling external funds and skills, particularly where single activity strategies are insufficient. However this may only help those with the political influence to help themselves. It also remains to be seen whether under such conditions, international finance would be interested. What is at issue is the degree of comprehensive, simultaneous action, the expenditure per recipient and the extent to which a new exotic authority is required.

2. As natural resources become more scarce, and the numbers of formal job seekers grow, there is probably a much greater role for an integrated approach by public authorities. This would be required to coordinate restructuring of production and society beyond the narrow base at present. Yet this may also require quite special conditions.

3. However the main problem of low rural living standards for the majority, and complex problems of poverty, could remain. IRD in Papua New Guinea conditions is no proven panacea for widespread improvement. This main problem will steadily worsen if marginal solutions cannot counteract adverse trends. But let us not throw the IRD baby out with the bath water.

REFERENCES


INTEGRATED RURAL DEVELOPMENT PROGRAMMES: SERVICES AND INFRASTRUCTURE OR VILLAGE LEVEL INTERVENTION? SOME EXPERIENCES FROM THE SOUTHERN HIGHLANDS

Will French

Institute of Applied Social and Economic Research, Port Moresby

ABSTRACT

The Southern Highlands Rural Development Project has attempted to stimulate rural development by two different approaches. The first is to increase the infrastructure and services provided by government; the project’s performance has been excellent in this regard. The second approach is to work within villages and to actively intervene in the rate and direction of village development, by providing job opportunities, new technologies, crops or literacy and numeracy skills. In this area the project’s performance has been lamentable. This paper considers the reasons for the failure of the project to intervene at the village level and concludes that they stem from poor project planning and inadequate project supervision. There are lessons here for those involved in planning and managing other interventionist projects whether they are Integrated Rural Development Projects or more traditional divisional outreach programmes.

INTRODUCTION

The Southern Highlands Rural Development Project (SHRDP) began in 1978. At a total cost of K25 million, it is Papua New Guinea's first major, and most ambitious, attempt to stimulate integrated rural development in one of its least developed provinces. In addition to economic development, the project emphasized the importance of social development by seeking to maintain the subsistence base of the rural sector, improve nutrition, and develop formal and non-formal education (Simpson 1980; Hinchliffe 1981).

This paper looks at the progress of the project and the problems encountered promoting development at the social level. It points to some lessons that are relevant to those planning village level interventions through integrated rural development projects, or through programmes involving more than one government department or division.
At first inspection the project certainly appears to justify its claim of being integrated: every arm of the provincial government participated in its planning. Its various components must subsequently have involved almost every government officer who works in the Southern Highlands Province (SHP). The objectives assigned (rather ungrammatically) to the project by the World Bank reflect its integrated approach:

"... a more equitable interregional distribution of income... and social services, satisfaction of basic needs. National integration and increasing the percentage of the population in the monetary economy.... The project would represent the first step in a long process of developing the economy of the province and helping the Southern Highlanders to raise their present low standard of living (World Bank 1978: p 13)."

The project adopted two main approaches to meet these objectives. The first was to increase and improve infrastructure and services provided by the government. The second was to work within village communities, and to introduce employment, new crops, technologies and skills and thus stimulate rural development through direct intervention in village life styles and village behaviour.

In Table 1 are listed the major activities in the project design. They are categorised according to which approach they follow in fostering rural development. (In addition to the two categories already described, I have included a third category called "research components" the primary aim of which is not "rural development" per se but the generation of the information that can be used to achieve rural development.) The classification is perhaps rather crude. It could be argued that the media unit aims to disseminate information at the village level and should be an "interventionist" activity. Conversely, tea blocks might be described as infrastructure since they are a centrally controlled investment.

In truth the two main categories are not mutually exclusive, and are better described as "ideal types". What ultimately has determined into which category an activity is placed is whether or not its success requires, to a significant extent, the active and permanent involvement and cooperation of village people. Thus, so long as the media unit continues in operation, it is regarded as a success according to the objectives specified for it (Integrated Development Authority 1978), even if its audience is restricted to government officers. On the other hand the viability of tea blocks depends to a large extent on local labour to pluck tea regularly at self help wages. On a number of occasions the tea blocks have in fact encountered serious disruption because of local level dissatisfaction with rates of pay (Macrae 1981).

Also described in Table 1 are the objectives of each activity and summaries of progress to June 1983. It provides some illuminating facts.
**Table 1. Southern Highlands Rural Development Programme activities: 1978 aims and 1983 Status.**

<table>
<thead>
<tr>
<th>Activity</th>
<th>IDA¹ aims</th>
<th>1983 status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. INFRASTRUCTURE AND SERVICES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tea factory</td>
<td>Construction and operation in 1982</td>
<td>Commenced operation in September 1983</td>
</tr>
<tr>
<td>Coffee factory</td>
<td>Construction and operation in 1978</td>
<td>Opened in March 1983</td>
</tr>
<tr>
<td>Electrification</td>
<td>60 km transmission line</td>
<td>Completed in 1983</td>
</tr>
<tr>
<td>Roads</td>
<td>Poroma - Koroba Highway; tea road; culverting</td>
<td>All except one tea road completed</td>
</tr>
<tr>
<td>High Schools</td>
<td>Construction and operation of two High Schools</td>
<td>Completed in 1983</td>
</tr>
<tr>
<td>Dauli agriculture teacher</td>
<td>Recruit and support agriculture lecturer</td>
<td>Not recruited</td>
</tr>
<tr>
<td>Nurse School</td>
<td>Construct and run a Nurse School</td>
<td>First intake 1983</td>
</tr>
<tr>
<td>In-service training</td>
<td>In-service training to health workers</td>
<td>In-service training established</td>
</tr>
<tr>
<td>Media Unit</td>
<td>Establish and support a media unit</td>
<td>Fully operational in 1982</td>
</tr>
<tr>
<td>AFTSEMU² extension training</td>
<td>train 70 DPT³ extension staff</td>
<td>Programme established in 1982</td>
</tr>
<tr>
<td>2. VILLAGE LEVEL INTERVENTIONS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Council coffee blocks</td>
<td>250 ha to be planted on 15 blocks</td>
<td>66 ha planted; 53 ha planted or in progress</td>
</tr>
<tr>
<td>Clan coffee blocks</td>
<td>45 clan blocks to be established, total 450 ha.</td>
<td>20 ha planted</td>
</tr>
<tr>
<td>Smallholder coffee</td>
<td>2500 smallholdings to be established, total 530 ha</td>
<td>None promoted by project</td>
</tr>
<tr>
<td>Coffee extension specialist</td>
<td>Recruit specialist to work with smallholders</td>
<td>Specialist not recruited</td>
</tr>
<tr>
<td>Tea blocks</td>
<td>800 ha tea to be established</td>
<td>220 ha planted; 40 ha in progress</td>
</tr>
<tr>
<td>Smallholder tea</td>
<td>125 smallholders, total 50 ha</td>
<td>Never undertaken</td>
</tr>
<tr>
<td>Tea extension</td>
<td>Provide staff and support for tea extension</td>
<td>Never undertaken</td>
</tr>
<tr>
<td>Cardamom</td>
<td>100 ha planted</td>
<td>20 ha planted; 15 ha in progress</td>
</tr>
<tr>
<td>Silk</td>
<td>To establish 40 ha mulberries, 400 smallholders, 8 sub-centres</td>
<td>Abandoned in 1981</td>
</tr>
</tbody>
</table>
Table 1. continued

<table>
<thead>
<tr>
<th>Activity</th>
<th>IDA(^1) aims</th>
<th>1983 status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-formal education (NFE)</td>
<td>Aid literacy, numeracy, nutrition, subsistence and smallholder business development</td>
<td>NFE now operationally defunct</td>
</tr>
<tr>
<td>Appropriate technology</td>
<td>Develop and promote appropriate village technology</td>
<td>Technologist never recruited</td>
</tr>
<tr>
<td>AFTSEMU village demonstrations</td>
<td>Conduct demonstrations of new crops, crop varieties, rotation and husbandry methods</td>
<td>Not a part of AFTSEMU’s programme</td>
</tr>
</tbody>
</table>

3. RESEARCH ACTIVITIES

<table>
<thead>
<tr>
<th>AFTSEMU</th>
<th>Generate information needed to effect changes in food crop production conducive to improving the quality of the diet</th>
<th>Continuing research (few reports yet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRU</td>
<td>To monitor the effects of indirect health inputs and development programmes on the health and nutrition of the target population</td>
<td>Continuing research (few reports yet)</td>
</tr>
</tbody>
</table>

\(^1\)International Development Agency.
\(^2\)Agricultural Field Trials, Studies, Extension and Monitoring Unit.
\(^3\)Division of Primary Industry.

Of the activities classified as "infrastructure and services" all, except one tea road and the appointment of an agriculture lecturer, have been completed and are now functioning satisfactorily. Some were expected to be operational more quickly than they were, and others (see Table 2) have exceeded their budgets by up to 25 per cent. However these are margins that are acceptable, and are to be anticipated for a complex project like the SHRDP.

When, however, we consider the activities whose objectives are village level intervention, the picture is strikingly different. Every one of these components has failed even to approach the objectives assigned to it, and many have never been seriously undertaken. The majority of this group of activities are aimed at promoting village level economic activity, and the most successful of these have been the tea and council coffee blocks, which have required the least commitment from village groups and relied most on the performance of the Mendi based Southern Highlands Management Authority (SHMA).

To achieve even their limited success both groups of activities are finding it desirable to minimise village level involvement. Although the coffee blocks are owned by local government councils who pay a management fee to the SHMA, in practice the councils are generally still ignorant of their ownership.
Table 2. Southern Highlands Rural Development Programme activities: 1978 costings, and expenditures to June 1983.

<table>
<thead>
<tr>
<th>Component</th>
<th>1978 costings (K'000)</th>
<th>Per cent of total</th>
<th>Cumulative expenditure (K'000)</th>
<th>Per cent of total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INFRASTRUCTURE AND SERVICES</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tea factory</td>
<td>937</td>
<td>5.21</td>
<td>863</td>
<td>4.96</td>
</tr>
<tr>
<td>Coffee factory</td>
<td>206</td>
<td>1.14</td>
<td>168</td>
<td>0.97</td>
</tr>
<tr>
<td>Electrification</td>
<td>430</td>
<td>2.39</td>
<td>540</td>
<td>3.11</td>
</tr>
<tr>
<td>Roads</td>
<td>7521</td>
<td>41.80</td>
<td>9123</td>
<td>52.46</td>
</tr>
<tr>
<td>High schools (Dauli Agriculture lecturer)</td>
<td>923</td>
<td>5.30</td>
<td>1190</td>
<td>6.84</td>
</tr>
<tr>
<td>Health sub-centres</td>
<td>302</td>
<td>1.69</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Nurse School In-service training</td>
<td>1266</td>
<td>7.04</td>
<td>1151</td>
<td>6.62</td>
</tr>
<tr>
<td>Media Unit</td>
<td>182</td>
<td>1.01</td>
<td>106</td>
<td>0.61</td>
</tr>
<tr>
<td>AFTSEMU (extension training)</td>
<td>No costings</td>
<td>No figures available</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>11797</td>
<td>65.58</td>
<td>13141</td>
<td>75.57</td>
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<tr>
<td><strong>VILLAGE LEVEL INTERVENTIONS</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Council coffee blocks</td>
<td>744</td>
<td>4.13</td>
<td>705</td>
<td>4.05</td>
</tr>
<tr>
<td>Clan coffee blocks</td>
<td>605</td>
<td>3.36</td>
<td>0</td>
<td>0.00</td>
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<tr>
<td>Smallholder coffee</td>
<td>133</td>
<td>9.74</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Coffee extension specialist</td>
<td>107</td>
<td>0.59</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Tea blocks</td>
<td>1924</td>
<td>10.69</td>
<td>1315</td>
<td>7.57</td>
</tr>
<tr>
<td>Smallholder tea</td>
<td>22</td>
<td>0.12</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Tea extension</td>
<td>60</td>
<td>0.33</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>Cardamom</td>
<td>147</td>
<td>0.82</td>
<td>35</td>
<td>0.20</td>
</tr>
<tr>
<td>Silk</td>
<td>335</td>
<td>1.86</td>
<td>294</td>
<td>1.69</td>
</tr>
<tr>
<td>Non-formal education</td>
<td>488</td>
<td>2.71</td>
<td>561</td>
<td>3.22</td>
</tr>
</tbody>
</table>
Table 2.  continued

<table>
<thead>
<tr>
<th>Component</th>
<th>1978 costings (K'000)</th>
<th>Per cent of total</th>
<th>Cumulative expenditure (K'000)</th>
<th>Per cent of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>VILLAGE LEVEL INTERVENTIONS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appropriate technology</td>
<td>103</td>
<td>0.57</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>AFTSEMU (village demonstrations)</td>
<td>No costings</td>
<td>No figures available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>4668</td>
<td>25.92</td>
<td>291</td>
<td>16.73</td>
</tr>
<tr>
<td>RESEARCH COMPONENTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AFTSEMU¹ (all activities)</td>
<td>1290</td>
<td>7.17</td>
<td>976</td>
<td>5.61</td>
</tr>
<tr>
<td>TRU</td>
<td>237</td>
<td>1.32</td>
<td>254</td>
<td>1.46</td>
</tr>
<tr>
<td>TRU computer</td>
<td>No budget</td>
<td>110</td>
<td></td>
<td>0.63</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1527</td>
<td>8.40</td>
<td>1340</td>
<td>7.71</td>
</tr>
<tr>
<td>TOTAL PROJECT ACTIVITIES</td>
<td>17992</td>
<td>99.99</td>
<td>17391</td>
<td>100.00</td>
</tr>
</tbody>
</table>

¹Agricultural Field Trials, Studies, Extension and Monitoring Unit.
²Excludes project management, project overheads, and allowances for contingencies and inflation.
Sources: World Bank (1978), Project Management and Southern Highlands Management Authority.

Meetings of the counsellors who are directors of the companies are called very rarely and, when they do meet, information originates from the SHMA and flows in one direction. No dividends have yet been paid to any of the council-owned companies, and it appears unlikely that they will see any significant benefits, except for a few job opportunities, for years to come.

The tea plantations are owned by the provincial government development corporation and there has never been any question of their control by local groups. Instead, the main benefits identified for village people by the project were the number of jobs that were offered. However a reduction in the area planted has already reduced job opportunities from the level envisaged by the World Bank. The high cost of the plucking labour force is forcing the SHMA to investigate the
introduction of mechanical plucking, which would cause decimation of the present labour force.

Of the economic components designed for smallholders, most effort was put into the silk industry until the national government unexpectedly withdrew support for it in 1981. Thus results of the silk project have not been beneficial. Unsatisfied expectations have been raised amongst smallholders, particularly in Pimaga, where there were no alternative income earning opportunities. The provincial government has now found itself forced into a position whereby, for the next three years, it has committed about ten per cent of its disposable project resources to restarting the industry, which is unlikely to show a profit, and will only benefit 400 smallholders.

Despite K927,000 (5.11 per cent of the project budget) being allocated for the purpose, no attempt has been made to promote clan or smallholder owned coffee or tea. Thus the economic activity in the project that required the greatest village level intervention has been entirely neglected.

Rather surprisingly perhaps, the only activity selected for intervention to improve nutrition and subsistence agriculture is non-formal education (NFE) (see Table 1) which has a number of other objectives to meet, and in practice has not expended much effort on food and nutrition. Significant resources have nonetheless been invested in NFE (see Table 2), which have been used mainly to recruit and support district NFE officers whose duties and responsibilities have never been well defined. As a result, although NFE has achieved some apparent successes, for example some village water supplies have been installed and some help has been given to literacy groups, there is considerable skepticism in the province about the real value of this work. In 1982 the NFE component was absorbed into the Division of District Services, and has since lost all sense of direction. It is now operationally defunct as a field service. Even so, NFE has performed better than appropriate technology which has never even begun.

The Agricultural Field Trials, Studies, Extension and Monitoring Unit (AFTSEMU) is the component most concerned with subsistence and nutrition. At the time of project design it was expected that AFTSEMU would be a multifunctional unit which would carry out village demonstrations of new crop varieties, rotations, and husbandry methods, in addition to research. However in practice the AFTSEMU team found that the project designers had underestimated the amount of research that was required before it could commence village demonstrations. As a result, like the other components of the project, AFTSEMU has not yet achieved any significant village intervention.

The overall picture drawn by this review of the project is that while it has been successful in increasing the level of services and infrastructure in the province, the project has largely failed to achieve any planned changes to the village way of life. The causes of this failure cannot be attributed to the inappropriateness of the Southern Highlands environment for the planned interventions, since in most cases they have not yet been adequately tested at the village level. In every instance the planned changes failed in their planning, through operational problems, or because they were never started. In some cases (notably the silk
project, and AFTSEMU's village demonstration programme) failure arose from inadequate project design. The inputs necessary to achieve the stated objectives of these activities were never properly assessed, and they were only discovered to be inadequate after the implementation had begun.

The silk project was too elaborate for its relatively small scale. Smallholders enthusiastically participated in the programme (Vele 1981), and it was therefore particularly unfortunate that it was not until 1981, three years after the project began, that the national government realised that it was expected to subsidise by K5000 or more each of the approximately 400 smallholders involved, and thus abandoned the programme.

In the case of AFTSEMU, one study of the Nembi plateau was undertaken (Allen et al. 1978) which sought to identify the causes of malnutrition, and to provide suggestions for overcoming it. However, this study led mainly to recommendations for further research, since it was apparent that the solutions to the malnutrition problem were not yet known, and necessary technical inputs such as new crop varieties were not available to give to village people.

A number of reasons for the failure of the Southern Highlands Management Authority to achieve its objectives for the tea and coffee plantations have been suggested (Macrae 1981; Millett 1983). Most have to do with the structure and management of the SHMA, the failure of the Development Bank to advance loans, and the inappropriateness of the plantations selected by the Management Authority, due to their isolation or poor soils. Both of the authors cited above attached relatively little responsibility for the SHMA's failures to local difficulties, such as the unskilled work force or dissatisfaction with minimum wage rates, although these certainly existed.

Most distressing of all the failures by the project to provide a positive intervention at the local level are those activities (smallholder cash cropping, and appropriate technology) that have not commenced even five years after the beginning of the project. These appear to have always been given a low priority by project management, the SHMA and the provincial government, even though, had they been successful, they (with the exception of smallholder tea which always appeared impractical) had a great potential to raise living standards and cash incomes. They suffered because they were never supported by influential officers in the Southern Highlands Province who could convince project management and the SHMA to get them going.

What then are the lessons to be drawn from these experiences? Firstly, it is far easier to design, organise and manage an "integrated" project that provides only infrastructure and services than one that contains activities that try to intervene at the village level. Project planners and management are more successful when they operate at a provincial than at a village level. The former is an environment with which they are familiar and which they know how to control. The World Bank and project management in the SHRDP appear to have taken this point. In discussing how unspent funds should be allocated (as shown in Table 2 most of these funds are the result of underexpenditure of village intervention activities), they have strongly favoured concentrating on additional infrastructure such as
additional school dormitory buildings and housing for government staff. Whether and in what way they believe this will promote rural development in the province is not clear.

The next and most fundamental point to consider is what it is that planners mean when they talk of integrated rural development, and how do they want to achieve it? This question is asked not to invoke the philosophical debate of what constitutes development, but rather to emphasise that when planning a complex project, the objectives, priorities and programmes must be more clearly specified than they were in the SHRDP.

The background papers prepared at the time the project was planned make it quite clear that village level activities were envisaged to be one of the major means of achieving the development sought, although this emphasis is not quite so prevalent in the *World Bank Staff Appraisal Report* (World Bank 1978) which has served as the official blueprint for the project. As time has passed, project management, with its understandable interest in achieving concrete and identifiable results, has chosen to retreat from the strategies first envisaged, and increasingly has concentrated on project activities centered in the provincial capital, which it has found easier to supervise.

It is sometimes suggested that, as government intervention has in the past proved so unsuccessful, government should concentrate its development efforts on providing the infrastructure and services that have succeeded so well in the SHRDP. This argument suggests that village level development should take care of itself. Whatever the validity of this point of view, if direct intervention is desired then it must be planned, organised and managed with far greater attention to detail than projects concerned with providing services and infrastructure.

A particular point to note here is that although much has been made of the fact that the SHRDP is a project that attempts to integrate social and economic programmes, integration in fact stops at the provincial level. The various project activities are scattered around the province: a tea plantation in one place, a health sub-centre in another, and a literacy programme in a third place. Few villages have experienced any sort of assistance in achieving integrated development under the project.

Whether or not the government's development efforts should be at the village level is fundamentally a philosophical question. Those who are engaged in such activities, whether they are in health extension, setting up clan coffee blocks or in literacy, have implicitly resolved these issues for themselves. For them, and more importantly for those planning their activities, the lessons from SHRDP are relevant. Their task is vastly more difficult than that faced by those planning infrastructure and services; it is indeed a task that Papua New Guinea has not yet effectively mastered. It generally involves operating in an unfamiliar and uncertain environment that requires unknown financial and technological inputs. It also demands considerable support and supervision from the higher government levels which, at present, they are often not sufficiently well organised to provide.
It is perhaps the failure to recognise the scale of these problems that has led to such consistently disappointing results in the various attempts that have been made by government to accelerate or change the course of village level development through its own intervention. Future projects, whether Integrated Rural Development Programmes (IRDPs), interdivisional provincial nutrition projects such as those recommended recently by the United Nations Development Programme (1983), or more traditional divisional outreach programmes, must therefore be particularly carefully planned if village level intervention is to be attempted with any real chance of success.

REFERENCES


health, commerce, and works continued to be left out of the "integrated" project, last minute alterations were made to include education. A sub-project was proposed that was intended to tackle the problem of malnutrition in the province. A project was then designed that would approach the problem through training teachers, and working with pupils in community schools, high schools and vocational centres.

**DEVELOPMENT OF THE PROJECT**

The Agriculture and Nutrition Education Sub-Project (AgNutSP) became the eighth "arm" of the ESRDP. It started in mid-1977 with the appointment of Tanam Kim, a former Community School Inspector, as the AgNutSP manager. Jim Tyler, a former science teacher at Vudal Agricultural College was appointed as an in-service lecturer. His appointment by the Education Department at Waigani (ESRDP was a national project commencing just prior to decentralisation) was bitterly opposed by DPI as they saw him as someone who was "anti-DPI". This appears to have set the basis for conflicts between Education and DPI that have continued through the life of the project.

A Provincial Education Advisory Committee was organised. At its early meetings, much concern was expressed over the contradiction of DPI's emphasis on cash crops, while the AgNutSP was to encourage the development of subsistence agriculture. Concern was also raised frequently over the neglect of women's groups. People were aware that if one wanted to do something about malnutrition, one needed to reach children between the ages 0 and 5 years, and not older (school) children. Those between 0 and 5 are the more vulnerable. Those that survive to school age are usually then alright. It was also recognised that to help young children one needed to educate mothers. However, year after year the project ignored these concerns. Instead, the AgNutSP directed its attention to children, the future parents.

The Asian Development Bank (ADB) when appraising the education sub-project as part of the ESRDP agreed to the "strengthening of facilities for the teaching of improved agricultural techniques and aspects of nutrition in local schools." A concern for today's mothers was lost. Instead between K800,000 and K1,200,000 has been spent in the past seven years on the training of teachers and future parents. Programmes that might have reached the more vulnerable 0-5 year old children have either been neglected, or directly opposed as a result of this emphasis.

1983 is the last year for the ESRDP as a national project. Steps have been taken this year to integrate the project more fully with the province. It is anticipated that in 1984 the eight sub-projects of the overall project will be transferred completely to the provincial government and continued as part of the East Sepik Province's recurrent budget. For the AgNutSP, K120,000 has been requested through the National Public Expenditure Plan (NPEP) process so that it might be fully institutionalised as a provincial programme. Yet the 1983-1987 Community School Plan and the 1983-1988 Non-formal Education (NFE) Plan for the province
make no mention of the AgNutSP or its complete integration with education (Kawan 1982).

Perhaps the most successful of the sub-projects has been the Sepik Agricultural College (SAC), but only because it is easier to build an institution than carry out a diverse programme. However, even the SAC has its problems, mainly because of the over-production of agricultural extension personnel, with the result that the Highlands Agricultural College has been transformed into an in-service training centre. If human resource requirements had been accurately forecast, the SAC might never have been built. All the other projects have run into delays, and costly overruns, and the buffalo and fisheries projects have suffered from severe disasters (disease and Salvinia molesta respectively).

In 1977 the total cost of the project was established to be over K15 million, including the new agricultural college, the education sub-project, and the income generating projects. It was anticipated that the income generating projects would produce by 1989 additional revenue amounting to K4 million per annum, from fish, rubber, coffee, rice, cocoa, copra and buffalo. Of these, only the rubber may actually meet the original objectives, but not without unforeseen problems (Bannister 1982; Story 1982; Willis 1982).

For the AgNutSP, 1977 was seen as a year of planning. East Sepik Province had 120 community schools at that time, compared to 175 in 1983 (counting "feeder" schools). In 1977 the AgNutSP set as an objective the creation of sixty "project schools", ten in 1978, 15 in 1979, 20 in 1980, and 15 in 1981. The eight vocational centres and five high schools were also to be slowly phased into the programme. Early planning, approved by the ADB, anticipated providing each project school with K700 worth of tools and supplies and building a nutrition shed worth K4000. In addition, an in-service training centre (ISTC) was to be built at Kunjingini (in the land-short Wosera Sub-district, south of Maprik Town).

The AgNutSP was to be staffed, in addition to the in-service instructor and the sub-project manager, by an applied nutritionist, an agriculturalist, and a farm machinery instructor. There were also positions for local counterparts, and fellowships for overseas training.

INITIAL CHANGES

Once the project started, many changes took place. The in-service training was never held at Kunjingini. Instead it was transferred to Wewak and held at St. Benedict’s Teachers’ College at Kaindi. The first course took place over the 1977 Lahara from November 1977 to January 1978. Plans were made to build an in-service training centre (ISTC) at Kaindi. These also were not acted upon. Instead, in-service training shifted first to Bagi then, due to conflicts between people and the Catholic Mission there, it was transferred to Saramandi Agricultural Research Station at Gavien, and when those facilities became unavailable, the courses were held in women’s clubs. Eventually the new ISTC at Gavien (across from Bagi), was opened in March, 1983.
Since the first eight week course in 1977-78, the agriculture and nutrition education in-service courses were reduced to a 12-day intensive course for project teachers, and a one-week course for headteachers, inspectors, and other interested people. This approach was developed by Elizabeth Cox who first became involved in the in-service training when she was a volunteer at the Bagi Agricultural Centre. Later she was hired as nutrition consultant. The AgNutSP embraced the approach to improving subsistence gardening that had been developed and proven over many years at Bagi (Tyler 1978; Cox and Tyler 1981).

Agriculture and small machinery consultants were hired after the appointment of Elizabeth Cox. Though all of the people occupying the five positions in the sub-project were meant to work together, only Cox and Tyler did, while the executive was more neutral, and the other two more distant. The basic problem was that people were hired who did not share the same understanding about the nature of the job. As the staff did not agree on the means to achieve the project objectives, the attainment of these objectives was seriously undermined. It is a credit to the devotion of the first mentioned two consultants that so much was eventually accomplished by the project.

An example of the divisions between the sub-project staff is seen not only in their inability to work together, but also in the fact that they lived in three separate places in the province. The nutritionist was at Gavien, the farm machinery consultant at Hayfield, and the agriculturalist in Wewak (where his children could attend an international school). The same situation exists in 1983. Despite three staff houses having been built at the Gavien ISTC, only the nutritionist, Hannah Ogi, has chosen to live there, while the other two staff live in Wewak. The division between staff has continued despite localisation.

Not only did the education sub-project staff not work together, but there was an even greater gap between them and most of the DPI staff involved in the other projects. This distance between the staff was accentuated by the DPI staff's view that the education staff were "against a cash-crop economy". Most of the DPI staff were involved in and committed to income-generating projects to the neglect of subsistence crops. This came to a climax in 1981 when a T-shirt was produced at Gavien for World Food Day in October which said: "Yumi no inap kaikai raba, osem moa gut yumi plainim bikpela gaten kaikai" (we cannot eat rubber, it is better to plant a large food garden). Some agricultural officers felt very threatened by this, over-reacted to this simple truth, and demonstrated their lack of a sense of humour by calling for deportations of education sub-project staff. So much for integrated rural development!

The AgNutSP changed in other ways over the years. During the first year, teachers who were identified as 'project teachers' were to be paid an incentive allowance after they had successfully completed an in-service course. This scheme was dropped during the first year of the project. The target schools selected, and the number of schools to become project schools slowly changed, from the original objective of slow increments of ten or fifteen each year to a realisation that one had to serve all schools in the province. What brought about this change was the inability of the province to regulate the assignment of project teachers to schools.
In the early days, project teachers would be trained, and then transferred to other schools that were not part of the original plan.

A system of target schools was unworkable. At this time, there are approximately 85 schools with no project teachers, while 90 schools have between them 117 project teachers. These are not equally distributed: 68 schools have one project teacher, 17 schools have two project teachers, and at least 5 schools have three. Transfers out of the province would have caused a loss of some trained project teachers, but it is not known how many have left over the years. As 140 project teachers were trained between 1977 and 1983, this would suggest that 23 of them have either left the province, retired, or are deceased.

In 1982 the five AgNutSP staff filed reports on 87 project teachers they had visited in the field. Of these, 56 per cent were ranked either A or B, 27 per cent were found to be fair, and 17 per cent poor in the level expected (and the judgments take account of adverse conditions). The staff were also committed to running a number of refresher courses for interested project teachers each year.

UNANTICIPATED PROBLEMS

A problem that developed, but was not anticipated in advance, was that the conflict between sub-project staff caused the key staff to reject some of the approaches of the others. The agriculturalist denounced (in writing) the nutritionist as a socialist and hippy and devoted his energies to working with high school agriculture, and developing an agricultural course for students in teachers' colleges. Students who have been through this pre-service course at Kaindi are awarded a "certificate", but the AgNutSP would not recognise them as "project teachers". Originally this was because of differences over the nature of the course (Longhurst 1981). Others have taught and now teach the course at St. Benedict's Teachers' college since the first agricultural consultant left the country.

The refusal to recognise the certificate teachers as project teachers has been partly justified on the grounds that they have not learned nutrition or nutrition cooking to the same degree as is taught in the 12 day intensive in-service at Gavien (specifically: to discourage boiling; encourage traditional baking, the regular use of coconut cream and better use of sago). The consequence of this, though, is that a pool of teachers who have a potential interest in promoting the project are not co-opted into it, and one way of increasing the number of project teachers is not fully utilised. All schools theoretically are project schools, and nearly all schools have been sent most materials and supplies, but teachers often feel they cannot make use of them without the additional training, and thus the materials remain in the schools unused.
NEW OBJECTIVES

As the project evolved, it also developed a multiplicity of objectives. Some of these were:

- production and distribution of agriculture and nutrition (AgNut) curriculum materials
- distribution of tools and cooking equipment to schools
- nutrition songs (books and tapes)
- weighing and measuring of school children and a nutrition record book
- a newsletter called ‘Better Life’
- regular visits to project teachers and schools
- one day in-service at schools on agriculture and nutrition
- National In-Service Training (NIST) week in-service on agriculture and nutrition
- water supplies for schools
- Village Level Extension Workers (VLEW)
- medicine kits to schools where there was no aid post
- nutrition games
- posters
- a nutrition calendar
- celebration of World Food Day, October 16th
- Raun Isi nutrition dramas
- fellowship training
- ongoing internal evaluation
- construction of the in-service training centre at Gavien
- establishment of a resource library at the ISTC
- working with women’s clubs
- development of slide sets for agriculture and nutrition education
- a manual on running AgNut in-service courses
- participation in the Provincial Agriculture and Nutrition Education Committee (PANEC)
- supporting research

The curriculum development efforts resulted in a series of inter-related materials on agriculture and nutrition education. These included the nutrition record books, the basic books on improved subsistence agriculture called Good Gardens, Good Food, the teachers' guide called Good Gardens, Good Food Book, the set of 18 posters to go with these, four posters on gardening methods, and five large posters on major themes, followed by the main handbook for teachers (and other extension officers) called Good Gardens, Good Food, Good Development. Two books of nutrition songs have been produced, the first by the Health Department, with cassette tapes to help students and teachers learn the songs (these may be among the most used and lasting impact of the project). All of these are available at a low cost from the Liklik Buk Information Senta in Lae at the University of Technology.

In addition, two readers have been produced for use in community schools. These are called Our Side of the Mountain which deals with conservation, and Good Gardens, Good Food Stories, a reader intended for Grade 5 which has 12 chapters covering such themes as nutrition, uses of garden produce, gardening methods, and others. The project also supplied schools with a calendar to plan their AgNut programme. A handbook for running the in-service courses has been produced. A recipe book for nutrition cooking is in preparation. The staff estimated that only 40 per cent of the schools used these materials effectively, while another 20 per cent used them "erratically". Their use was blocked by headteachers in 10 per cent of the schools, and they never reached the remaining 30 per cent.

There was also a high school and vocational centre component to the original project. Both of these had lost momentum by 1981. The vocational centres in the province were renamed Village Development Centres (VDCs), but this remained a change in name only as the staff were not given any re-training or direction. Also, most of the existing managers were hostile to the change, and effectively blocked its implementation. In a few instances some effective village-based training was carried out, but it was never sustained from one term to the next.

The five older high schools (there are now three new high schools) received some assistance in the form of tools, and some of them actually built either a new classroom or a nutrition and agricultural education building with the use of sub-project funds. The new syllabus developed by the agricultural consultant was acceptable to them. Some special in-service training courses have been held at Gavien for high school teachers. However, the major emphasis of the AgNutSP has been on community schools.
mobility of teachers in the system. However, better teachers who want to transfer could be encouraged to transfer within the project.

Given the original objectives of the AgNutSP they could best be achieved by working directly with the community. This the staff have done by promoting and working with Women’s Clubs in East Sepik Province as an extra-curricular activity to which the sub-project staff were dedicated. The PANEC in December 1982, accepted it as one of Hannah Ogi’s duties (assistance to women’s programmes through the East Sepik Council for Women). Yet their efforts in this direction have never been given the support by people in the province that they deserved.

Training programmes for women through women’s clubs is left completely out of the East Sepik Province’s Non-Formal Education (NFE) Five Year Plan. However, if one is to help improve the agriculture and nutrition that affects children in the age range 0-5 years, this can best be done by programmes with mothers. Very few schools in the province have been able to work with mothers effectively or do any extension into the community. A few have involved parents and worked with Women’s Clubs. This is where people originally saw that the AgNutSP was deficient and where it remains lacking today.

The project needs revitalisation if it is to make a contribution to what happens in community schools in the province. Having two level seven officers is a mistake. Two chiefs and one Indian has not made for smooth operations in 1983, particularly when the two officers are so different in outlook, level of commitment, and orientation. A hierarchy needs to be created with one level seven, a level four or five extension officer, and a level three or four assistant to help run the ISTC. Given the existing situation these officers could all be placed under the provincial government, responsible to the Provincial Agriculture and Nutrition Committee with representatives chaired by the Officer-in-Charge of Training.

It is essential after all these years that the province learn one of the major lessons of the history of this project, and appoint to these positions only staff that are in agreement with the orientation of the project, committed to obtaining its objectives, and willing to spend the time required on the project (like making school visits). Under the terms of the project, all three positions must be advertised and open to all candidates.

**SUMMATIVE EVALUATION**

By the time of its completion, the evaluation will have comprised the components listed below.


2. Visits to institutions (40 community schools, five high schools, five VDCs, and St. Benedict’s Christian Training Centre).
3. Interviews where possible with other relevant staff (NFE, inspectors, provincial government).

4. Administration of an agriculture and nutrition test to Grade 6 pupils in selected community schools.

5. Administration of a materials questionnaire to teachers in the sampled schools.

6. Post card questionnaire no. 1 to all 168 community schools (not including feeder schools) in East Sepik Province during the first term of 1983.

7. Post card questionnaire no. 2 to all 168 community schools (not including feeder schools) in East Sepik Province during the fourth term of 1983.

8. Examination of evaluation instruments used by the AgNutSP:
   (a) nutrition record cards;
   (b) nutrition aids evaluation form, September 1982;
   (c) project teacher evaluation form, September 1982.

9. Study of all relevant documents.

10. Reading of all relevant project files.

This evaluation of the AgNutSP of the ESRDP will therefore take some time. It will not be completed until early 1984.

REFERENCES


FARMING SYSTEMS RESEARCH: ITS PLACE IN THE AGRICULTURAL COLLEGES AND UNIVERSITIES AND ITS ROLE IN PROMOTING FOOD PRODUCTION IN PAPUA NEW GUINEA

Samuel B. Lahis

Agricultural Education and Training Division, Department of Primary Industry, Konedobu, N.C.D.

ABSTRACT

This paper discusses the concept of farming systems research (FSR) as a strategy to promote increased food production by the involvement of farming households, specialists in the biological, physical and social sciences, training institutions, and extension staff. Current training efforts in the agricultural colleges in food production are reviewed, and the constraints placed on them are discussed. The FSR approach is defined, and the processes and activities involved in implementing an FSR programme, as well as training objectives in FSR methodologies are discussed as a background to what can be achieved by agricultural training and research institutions in Papua New Guinea. The final part of the paper discusses the role of agricultural colleges and universities not only in providing training in FSR but also in the actual implementation of FSR programmes in Papua New Guinea.

INTRODUCTION

Bourke, Carrad and Heywood (1981) identified a number of priority areas needing action, both directly in food production and also at a policy level, in order to address Papua New Guinea's food problems. Two areas which were identified and are of special interest to this conference are training and research in food production and nutrition at the Department of Primary Industry (DPI) institutions.

The purpose of this paper is to discuss the concept of farming systems research (FSR) as a strategy to promote increased food production through the joint involvement of farming households and families and specialists in the biological, physical and social sciences, training institutions, and extension staff. The paper is divided into four parts. The first part reviews the present training efforts in food production in the agricultural colleges in Papua New Guinea (PNG), and the constraints placed on them. The second part introduces the concept of FSR, and describes the processes and activities involved in implementing an FSR
programme. In the third part, training objectives in the FSR methodology and processes, and assistance that is possible from countries with on-going FSR programmes are outlined. The final part discusses the role of agricultural colleges and universities, not only in providing training in FSR, but also in the implementation of FSR programmes in Papua New Guinea.

**TRAINING IN FOOD PRODUCTION AT DPI COLLEGES**

It is often alleged that agricultural colleges have in general failed to produce graduates competent to assist in the food production industries, and that graduates have been particularly weak in the field of subsistence agriculture and traditional crops (Bourke *et al.* 1981). Perhaps it is more accurate to state that colleges have previously not emphasised training in subsistence and traditional food crops in their curricula. The colleges have followed departmental policy which emphasised cash crops and livestock production (*e.g.* cattle, pigs). I do not consider that the allegation is an accurate or fair assessment of what the agricultural colleges have been required to produce in terms of graduates with a general education (*i.e.* a broad understanding) in agriculture.

There are other factors which limit the ability of the colleges to contribute effectively to the training of its graduates in subsistence and traditional food crops. The colleges are located in different ecological ‘zones’ which are also culturally different. It is difficult, therefore, for all the colleges (of which there are four) to cater adequately for the different ethnic groups attending the colleges, and to provide training in a particular region’s subsistence and traditional food crops, as well as covering other regions. The best that can be achieved within the curriculum is to concentrate on a few major farming systems and traditional crops of a region (*e.g.* the highlands) and to expose students to the agronomy and cultural practices, both traditional and improved, in the locality of the college. There is also the view that students attending our colleges would have been exposed, in one way or another, to traditional crops in their home areas. They possess some skills and knowledge already that cannot be covered in the curriculum at the colleges.

The teaching of traditional crops, and their traditional production methods, by a teacher from a different region (an expatriate for example) can be unproductive and sometimes scorned by students, especially if a student from a different region knows that the instructor is not from the area about which the traditional agricultural practices are being discussed. Similarly, students from the region who are familiar with the traditional practices relating to a food crop (*e.g.* yam) being discussed may also question the authority of the instructor on the matter. For example, a few years ago a group of coastal students attending the Vudal Field Station at Mt. Hagen questioned why they were taught how to grow sweet potato using drains (barets) and square mounds as practised in the Mt. Hagen area. As coastal students, they were used to growing sweet potato in round mounds and they did not see the need to be taught the Mt. Hagen way, because it was hard work!
The main point is that the potential for exposure of students from different ethnic and cultural backgrounds to the traditional practices of food production of any group or region is limited at agricultural colleges. The colleges are however attempting to blend traditional methods with mechanisation in the production of food crops, as part of their instructional programmes. Curricular changes in recent times have increased the emphasis placed on both traditional food crops and introduced vegetables in the teaching at the agricultural colleges. This is a significant change, but the effort needs to be expanded and extended to farming families and communities near the colleges. Bannister (1982, p. 521) summed up the major constraints faced by the colleges this way:

"Given the diversity of subsistence agriculture and the time available (to teach courses), the scope of the course (i.e. 2-year certificate) is limited. The main agricultural systems used in Papua New Guinea are covered as are the main staples. The student is expected to become reasonably familiar with the practical requirements of growing the main staple crop in the area where the college is situated. Whatever is done, no graduate will be as proficient as the village farmer in the techniques of traditional food production.... The college can give graduates a broad understanding of the systems that are used and how improvements could possibly be made. This provides the broad framework within which can be fitted the specific recommendations that the researchers may make when the graduate is a field extension officer."

The suggestion by Bourke et al. (1981) to place greater emphasis at the agricultural colleges on subsistence and commercial food production, with particular attention being paid to problem identification and the use of technologies that can be applied immediately, is applauded. As stated earlier, the colleges have moved in that direction, but they must now take up this challenge by making and implementing appropriate curricular changes. However, the colleges must be careful that the types and levels of technologies that they are trying to promote are not too sophisticated for themselves and for the farmers who will be the ultimate users of the technologies.

Agricultural colleges and universities should be seen as places where new technology is introduced, adapted and slowly made available to the farming communities. This may sound threatening to extension related agencies, who traditionally have viewed themselves as the link between research, development and the farming community. However problems should not arise if colleges, universities, research institutions and even private enterprise are closely involved in adapting and promoting technology that will benefit the farming community.

Likewise, in the area of research and development of food and cash crops, DPI research stations have treated this area as their exclusive domain. They have collaborated very little with other agencies and communities outside their own spheres of influence in many of their research programmes. In the past, little collaborative or adaptive research has been carried out between DPI research stations and the colleges, universities, or farming communities where they are located. Thus these latter organisations often have had scant data on which to
to give team members guidance and experience working as an interdisciplinary team;

(3) to instill in the team members an enlightened appreciation of small farmers as a useful source of information, and valuable partners in the research and implementation process.

I believe it is not too difficult to initiate, on a small scale, an FSR programme with a view to acquaint selected people with the FSR approach and methodologies. Furthermore, we should be sending selected staff overseas to centres with on-going FSR programmes, both as a training activity and to gain experience.

**ROLE OF AGRICULTURAL COLLEGES IN FSR AND DEVELOPMENT**

Initially FSR programme leaders and selected staff from the agricultural colleges and universities should take advantage of production and farming systems training at one or more IARCs and regional centres or training institutions specialising in applied agricultural research. With such training as a base, in-country training programmes for both extension and research staff can be developed and implemented.

I believe our agricultural colleges and universities can play a vital role in initiating and eventually providing training in FSR. These institutions can also play an important role in implementing FSR programmes since they are located in different regions of the country and are closely identified with communities in which they are located. I suggest, therefore, that FSR be included in the curriculum of agricultural colleges, especially the diploma programme, as well as the degree programmes at the two universities. I do not consider that it would be difficult to incorporate FSR into the diploma curriculum presently taught at the agricultural colleges. For the certificate course, it may be included not so much as FSR *per se*, but FSR concepts can be integrated with the 'Practical Food Crops Production' course, and nutrition and extension patrols. Therefore some mechanisms exist already in our colleges to integrate FSR activities into the college curriculum.

The agricultural colleges have already taken the initiative to introduce new curricula for certificate and diploma programmes. In both cases, food crop production and management are emphasised. I am confident that we have made the right decision when reviewing our curriculum to suit changed circumstances. We have critically looked at our past performances and have adjusted our courses based on the findings of McKillop *et al.* (1982). This year is the first year of implementing changes recommended in their report. We are still experiencing some problems, but we hope that the next two years will give us sufficient time to solve these, and face the challenge of producing graduates skilled in the science of food production.

The colleges and the universities have tremendous potential to contribute much more to solving food problems and food production in Papua New Guinea than has been seen in their efforts to date. Much of the past effort has been uncoordinated.
and therefore ineffective. More collaborative work involving interdisciplinary teams from different government agencies is urgently needed to address the food problem. Farming systems research and development provides a basic framework for a successful strategy to promote and increase food production in Papua New Guinea, through the active involvement of our training and research institutions and inclusion of FSR in their curricula activities.

REFERENCES


ABSTRACT

The 1947 New Guinea Expedition was the first attempt to collect nutritional data in Papua New Guinea. The main conclusion of the expedition report was that the village populations in the study area were suffering from protein deficiency. There have been numerous subsequent nutrition surveys collecting anthropometric and dietary data. Growth retardation has been documented in highland and lowland areas throughout the country. National Nutrition Surveys, using data collected during Maternal and Child Health clinics, were conducted in 1975 and 1978 but their validity is questionable on a number of counts. The fieldwork for the third National Nutrition Survey is currently in progress. Approximately 35,000 under five year olds from all Districts in the country are to be measured. Selection of survey villages was made using a sample frame based on the physical environment.

Although there are marked differences in the levels of growth between different areas, the general pattern is the same. There is a rapid fall in weight-for-height during the first year of life. This decline continues in subsequent years, with the lowest level being reached during the third year. Height-for-age decreases rapidly over the first five years of life. Weight-for-age is a reflection of the other two indices. Low levels of growth are associated with poor health and increased risk of death. Various theories have been suggested to explain the pathogenesis of childhood malnutrition. In the mid-1970s the emphasis changed from protein deficiency to energy deficiency. More recently, it has been suggested that additional factors, including cultural practices relating to the introduction of first foods, should be considered if nutrition education programmes are to be successful.

Secular studies have indicated an improvement in childhood growth in areas which have undergone significant economic development over the past thirty years. Increased height growth and lower infant and child mortality have been associated with marked changes in the diet,
particularly increased intake of cereals and animal protein. However, some dietary changes have been accompanied by an increase in the incidence of degenerative diseases, especially diabetes mellitus. The aspects of dietary change which have resulted in an increase in child growth should be encouraged, whereas those associated with health problems need to be discouraged.

INTRODUCTION

The first people arrived in Papua New Guinea (PNG) over 30,000 years ago, probably from Asia by way of Indonesia, and over a considerable period of time. It appears that the earliest peoples were hunters and gatherers, not agriculturalists. Later migrations introduced agriculture, particularly plants such as taro, yam, sugarcane, bananas, green vegetables and fruits, and the pig, and these are all important food items today. Along the coast, the sago palm and the coconut, together with seafood, were also important. A large migration of population to the highlands is thought to have occurred with the introduction of the sweet potato about 300 years ago.

Prior to the coming of the earliest European coloniser, food production was carried out exclusively at a subsistence level, with trade in general being restricted to a few foods of high status such as salt, betel nut and fish in certain areas. Only along the Papuan coast was there significant trade in sago and vegetables. In the late nineteenth century, Germany and Great Britain both established protectorates on the eastern portion of the mainland and the islands.

Outside the region there was, and still is, a strong idea of the Pacific as a region of "subsistence affluence" before Western impact. Part of the romance of the South Seas has been its image as a land of plenty where, in Byron's words, "....all partake the earth without dispute, and bread itself is gathered as a fruit."

The evidence for food abundance in the past is fragmentary and it is difficult to know what was the real situation. Some observers have, however, concluded that Pacific Islanders were amply fed at the time of western intrusion into the region except during times of occasional drought and frost.

Today these countries for which the image had been one of food abundance are increasingly reliant upon imported foodstuffs which formed 20-30 per cent of their expenditure on imports in the early 1970s. It has been estimated that in 1976 twenty-three per cent of all food consumed in Papua New Guinea was imported. As part of its attempt to develop a national food and nutrition policy, the government carried out a national nutrition survey in 1978. In this survey, it was estimated that the malnutrition rate (the proportion of children less than 5 years of age who are below 80 per cent weight-for-age based on the Harvard standard) was 38 per cent. In one province the reported value was over 60 per cent.

Judged by these figures, malnutrition is one of the most important public health problems in Papua New Guinea. Although the consequences of malnutrition are
more evident in health, the solutions lie in a number of different sectors, including agriculture, health education, and economic development. We have too little information about the objectives of programmes which could be developed in these various sectors.

In our attempts to understand this uncertainty and for planning for the future, it is helpful to look at previous nutrition research in Papua New Guinea and the backdrop against which it was performed.

**THE NEW GUINEA EXPEDITION IN 1947**

This expedition, carried out by the Australian Department of Health for the Australian Department of External Territories, was the first attempt to take a broad look at nutrition in Papua New Guinea (Hipsley and Clements 1950). The primary reason for the investigation was to obtain data on the food consumption patterns of village people as a basis for devising ration scales for labourers. Information on the nutritional status and health was collected on the same groups of people. It was also hoped that the data could be used in the investigation of future food shortages and in formulating policy with respect to cash cropping.

Five villages were chosen to represent areas dependent on the various staple crops of the country. They were:

(1) Busama, a village on the north-east coast close to Lae where the dominant staple food was taro;

(2) Kaiapit, which is in the Upper Markham valley 60 miles from Lae at an altitude of 1000 feet where the staple crops were banana and sweet potato;

(3) Patep No. 2, fifty miles from Lae at an altitude of 3550 feet, where the staples were sweet potato and taro;

(4) Kavitaria, a coastal village in the Trobriand Islands where the staple food was yam; and

(5) Koravagi in the Purari river delta of the southern part of the island of New Guinea, where the staple was sago. (Little useful data was collected from this village.)

As part of the survey, physical examinations were made of more than 1000 people of all ages. A 24-hour weighed food intake study on a household basis was carried out on 812 people. Anthropometric measurements were made on more than 1200 subjects. In addition the expedition document includes reports on anthropology, agriculture, parasitology, biochemistry and dental health.

The energy and protein intakes estimated from the dietary surveys were expressed in two ways. Firstly, on a per capita basis (see Table 1), and secondly as a percentage of the recommended dietary allowances (RDAs) (see Table 2). For
Busama, Kaiapit and Patep villages the daily per capita intake of protein was less than half of the RDAs.

However, per capita daily energy intakes were a much higher proportion of the RDAs. The lowest was 67 per cent at Busama. When interpreting these results it is important to note the actual RDAs used, which were based on the 1945 RDAs for the USA.

The values of the RDAs for energy and protein are shown in Table 3. The most striking aspect of the values for protein is the two and one half fold increase for lactation and the more than two-fold increase for pregnancy. The increases for energy are much less marked.

Table 1. Energy and protein intakes per capita per day of the households surveyed in four villages surveyed in 1947 (Hipsley and Clements 1950).

<table>
<thead>
<tr>
<th>Village</th>
<th>Energy (KCals)</th>
<th>Protein (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Busuma</td>
<td>1223</td>
<td>19.2</td>
</tr>
<tr>
<td>Kaiapit</td>
<td>1609</td>
<td>24.8</td>
</tr>
<tr>
<td>Patep</td>
<td>1904</td>
<td>24.4</td>
</tr>
<tr>
<td>Kavitaria</td>
<td>1600</td>
<td>41.3</td>
</tr>
</tbody>
</table>

Table 2. Energy and protein intakes per capita per day expressed as a percentage of the recommended dietary allowances (RDAs)\(^1\), for four villages surveyed in 1947 (Hipsley and Clements 1950).

<table>
<thead>
<tr>
<th>Village</th>
<th>Energy (% of RDA)</th>
<th>Protein (% of RDA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Busuma</td>
<td>67.2</td>
<td>33.7</td>
</tr>
<tr>
<td>Kaiapit</td>
<td>87.8</td>
<td>47.0</td>
</tr>
<tr>
<td>Patep</td>
<td>102.0</td>
<td>46.0</td>
</tr>
<tr>
<td>Kavitaria</td>
<td>81.7</td>
<td>81.7</td>
</tr>
</tbody>
</table>

\(^1\)See Table 3.
Although details are not given in the expedition report, it is almost certain that then as now, a very high proportion of women would have been either pregnant and/or lactating. The high RDAs used for protein and a high proportion of lactating and pregnant women are likely to have been major factors contributing to the marked apparent inadequacy of per capita intakes, particularly of protein, when expressed as a proportion of the RDAs as shown in Table 2.

The general growth pattern as revealed by the cross-sectional anthropometric data shows a marked departure from the Harvard growth curve. The physical examinations showed very few physical signs of nutrition deficiency with the exception of goitre at Kaiapit.

### Table 3. Recommended dietary allowances used for calculations given in Table 2.

<table>
<thead>
<tr>
<th>Category</th>
<th>Energy (KCal)</th>
<th>Protein (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MEN:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age 21-49, 54 kg</td>
<td>2500</td>
<td>40</td>
</tr>
<tr>
<td>Age 50+, 48.6 kg</td>
<td>2000</td>
<td>40</td>
</tr>
<tr>
<td><strong>WOMEN:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age 21-49, 46 kg</td>
<td>2100</td>
<td>40</td>
</tr>
<tr>
<td>Age 50+, 40 kg</td>
<td>1600</td>
<td>40</td>
</tr>
<tr>
<td>During pregnancy</td>
<td>2100</td>
<td>85</td>
</tr>
<tr>
<td>During lactation</td>
<td>2600</td>
<td>100</td>
</tr>
<tr>
<td><strong>CHILDREN UNDER 12 YEARS:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age 1 year, 8.2 kg</td>
<td>850</td>
<td>35</td>
</tr>
<tr>
<td>Age 2-3 years, 11.2 kg</td>
<td>1000</td>
<td>40</td>
</tr>
<tr>
<td>Age 4-6 years, 15.5 kg</td>
<td>1300</td>
<td>50</td>
</tr>
<tr>
<td>Age 7-9 years, 20.9 kg</td>
<td>1650</td>
<td>60</td>
</tr>
<tr>
<td>Age 10-12 years, 27.3 kg</td>
<td>2000</td>
<td>70</td>
</tr>
<tr>
<td><strong>CHILDREN OVER 12 YEARS:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boys, age 13-15, 35.4 kg</td>
<td>2400</td>
<td>85</td>
</tr>
<tr>
<td>Boys, age 16-20, 49.5 kg</td>
<td>2900</td>
<td>100</td>
</tr>
<tr>
<td>Girls, age 13-15, 35.9 kg</td>
<td>2200</td>
<td>80</td>
</tr>
<tr>
<td>Girls, age 16-20, 46.4 kg</td>
<td>2050</td>
<td>75</td>
</tr>
</tbody>
</table>
In the conclusions of the expedition report, the dietary data are given greatest weight and the major emphasis is on protein deficiency. This is despite the fact that no account is taken of seasonality of food intake and all dietary data are reported in terms of per capita household intake. The report fails to address the paradox of this conclusion, that no physical signs of protein deficiency were observed.

From the time of this initial investigation there was an increase in interest in nutrition in Papua New Guinea. In the 1950s there was further extensive documentation of growth retardation by Scragg (1955); McKay (1960); Oomen and Malcolm (1958); and Venkatachalam (1962). The first documented report of kwashiorkor was made by Venkatachalam and Ivinskis (1957) in Simbu Province. This study included anthropometric measurements, estimation of food and nutrient intake, physical examinations and some laboratory investigations. The general pattern of growth retardation was confirmed, and the general conclusions placed considerable emphasis on protein deficiency, particular in young children. It is important to note that (1) the same RDAs were used as in the 1947 expedition report; (2) again no account was taken of seasonal or cultural factors affecting food availability and intake; and (3) only one child under three years of age was included in the food intake study.

In response to the documentation of malnutrition as an important health problem, the Public Health Department established a Nutrition Unit in Simbu Province in the early 1960s. This unit provided further documentation of slow growth rates (Bailey 1964). Studies of lactation indicated low breast milk intakes (Bailey 1965). In retrospect it should be noted that the methods used in these studies were particularly disruptive of the normal daily routine of the mothers and of the usual mother-infant interaction. Consequently these studies may have considerably underestimated habitual breast milk intakes. Other studies showed an appreciable incidence of nutritional oedema in lactating women (Bailey 1964). From dietary studies in a wide range of age groups it was concluded that protein intakes were about 50 per cent of the estimated requirements at all ages, and that energy intakes were low in infants and school-age children (Bailey and Whiteman 1963). Again it must be noted that these dietary studies paid little attention to seasonal or cultural factors affecting variations in food intake.

Further documentation of slow growth was also provided during the 1960s by the extensive work of Lawrence Malcolm in a number of different areas of Papua New Guinea. His important study of growth in Bundi (Malcolm 1970), a highlands area of Madang Province, provided strong evidence of genetic influences on growth rate. Malcolm suggested that genes for rapid growth and tall stature had been selected against. On the basis of studies of the effect of energy and protein supplementation on the growth of 7 to 9 year old school children, he concluded that a low protein intake was the most important constraint to growth.

A number of other studies in the 1960s showed that although highlands adults had low protein intakes they also had high levels of physical fitness (Sinnet 1975; Hipsley and Kirk 1965). This paradox led Oomen and Corden (1970) to propose that Papua New Guineans have present in their gut nitrogen-fixing bacteria, and
H/A. After a second year this continuing decline in W/A is largely due to a continuing slow fall in H/A.

Although the general pattern in similar, there are marked differences in the levels of growth between areas, depending on the indicators used. Thus, for example, children in Tari, Enga, Simbu, and lowland Madang have similar levels of W/A. However, at any given age lowland Madang children are generally taller and thinner than highland children.

The level of growth of children in Menyamya and Anguganak is much lower than in the other areas mentioned, for all three indicators. A particularly striking feature of these differences is the markedly lower levels of W/H in Anguganak and Menyamya, where the proportion of children below 80 per cent W/H is much higher.

Thus, it is clear that there are differences in growth in different parts of Papua New Guinea, but the extent to which these represent genetic and/or environmental influences is not clear (Heywood 1985). It is known that in the Tari area of the highlands of Papua New Guinea low levels of W/A are associated with significant increases in the prospective risk of death. This is also true of W/H and H/A (Heywood 1982). These results indicate that low levels of growth are a significant factor in health, but it is not clear to what extent the cut off points are the same in each area.

Perhaps the most striking point to emerge from these various recent growth studies is the extent to which growth failure is occurring early in life. In all areas, even in those in which early growth approximates international standards, W/A begins to fall markedly before six months of age, and in some cases as early as three months of age. It seems clear that for many children this pattern of growth is associated with feeding patterns where breast milk alone is inadequate to support growth beyond three or four months of age, and that the supplementary foods which are being introduced are inappropriate and too little and too late (Jenkins et al. 1984). Within this pattern of growth, variation is affected by a number of other factors. These include genetic factors and maternal nutritional status with its consequent effect on birth weight and lactation. The importance of this early growth failure is that it is an important determinant of subsequent growth. Unless there is a marked change in the environment and in the nutrient intake of the child, subsequent growth is maintained at this reduced level. Thus, one of the target points for intervention is in the first year of life, and particularly during the period when the departure from growth standards commences and becomes rapid.

Among the interventions which attempt to change feeding practices of women of child-bearing age and of infants, infant feeding practices are more likely to be successful if they are based on information about current feeding practices and maternal beliefs and the behaviours underlying them. Recent work at the Institute of Medical Research (Jenkins 1983) has shown that mothers have quite specific beliefs about infant feeding, a knowledge of which would be very useful when planning nutrition education programmes. As an example, amongst the lowland Madang people of Madang province child development is seen as
proceeding through a series of named stages marked by changes in motor
development and tooth eruption. These beliefs contain prescriptions about what
foods are appropriate for young children and the proper time at which they should
be introduced. The success of nutrition education programmes which fail to take
account of these beliefs is bound to be limited.

SECULAR TRENDS IN GROWTH

There have been a number of changes in food consumption patterns since the
beginning of the colonial period, which have been associated with major social and
economic development. Whether these changes have been associated with an
improvement in the growth of children is difficult to assess because baseline data
does not exist for most parts of the country.

One of the few places in which adequate documentation of changes in growth over
a period of time can be made is Simbu Province. Venkatachalam (1962) carried
out a cross-sectional growth study of children in Simbu Province in 1956. In 1981,
a Province-wide cross-sectional study of growth in children was carried out by
Harvey and Heywood (1983). These two studies allow an assessment of changes
in growth over a period of 25 years in which rapid economic development has
taken place. In 1956 the mean W/A of children 6-13 months of age was 80.2 per
cent (with a standard deviation (SD) of 11.77 per cent). By 1981 the mean W/A
of the same age group had increased to 88.4 per cent (SD = 11.11 per cent).
Children at age five years were approximately 2 kg heavier and 6 cm longer in
1981 than they were in 1956. The significance of this improvement in growth can
be assessed using the relationship between nutritional status and prospective risk
of death, estimated in the Tari Basin of the Southern Highlands Province
(Heywood 1982). The improvement has been sufficient to account for a very
substantial reduction in infant and childhood mortality.

Because baseline data does not exist for other areas of the country, it is not
possible to assess the extent to which growth has improved. However, it is known
that there has been similar rapid economic development in a number of other
parts of the country, and particularly in some highlands provinces, and it is likely
that similar changes in growth have occurred:

In Simbu Province these changes in growth have been associated with marked
changes in dietary patterns (Harvey and Heywood 1983). Protein intakes for all
age groups were higher in 1981, compared with 1956, whereas energy intakes
were similar for adults, but higher for children and adolescents. Whereas in 1956
sweet potato contributed 76 per cent of total energy intake and 56.3 per cent of
total protein, in 1981 it accounted for 53 per cent and 34 per cent, respectively.
In contrast the contribution of cereals and grains had increased from 4 per cent
of total energy and 5 per cent of total protein in 1956 to 22 per cent of total energy
and 25 per cent of total protein in 1981. The proportion of the increased protein
intake contributed by fish and meat had increased from 11 per cent in 1956 to 18
per cent in 1981.
Other instances of documented dietary changes in Papua New Guinea have been reviewed by Heywood (1981). Although there are no anthropometric data associated with these studies, it is reasonable to assume that similar changes in growth have occurred in some of these areas.

There is also evidence that these dietary changes have been accompanied by not only changes in growth but also increases in the incidence of various degenerative diseases of adults. Diabetes mellitus, in particular, appears to be increasing in a number of groups in Papua New Guinea, and amongst the Tolais of East New Britain Province and some Papuan groups it is now a very significant health problem (Martin et al. 1981). More recently, King et al. (1984) have studied diabetes in two villages in Eastern Highland Province which have different involvement in the cash economy. The different levels of cash income are associated with different degrees of reliance on purchased foods. Those with the higher income purchased a greater proportion of their total food intake. There were no diabetics diagnosed in either village. However, the mean blood glucose level measured after a glucose tolerance test was significantly higher in the village with the higher cash income. Although these results are preliminary, they do suggest that diabetes may emerge as a health problem in these groups as economic development proceeds. There is clearly a need to determine those aspects of dietary change which are beneficial in terms of improved growth of children and to encourage them, and to discourage those aspects which are associated with the development of other health problems, particularly in adults (Heywood 1981).

**NUTRITION SURVEILLANCE**

Evidence was presented earlier in this paper of the variation in levels of growth of young children throughout the country. Although this is a useful indicator of the diversity which exists, it has little value when determining priority areas on a national basis for nutrition intervention. For this, national surveys must be carried out.

Two previous national nutrition surveys, in 1975 and 1978, have been carried out in Papua New Guinea. Their aims were to identify the nature and extent of nutrition problems, and to determine areas and groups in which malnutrition was serious. Both of these surveys utilised data on young children collected through MCH clinics and have been criticised on a number of grounds. The attendance at MCH clinics was highly variable within and between provinces and between surveys. As a result the extent of the sampling error is unknown and, at least in some cases, likely to be very large. The accuracy of the comparisons made in these surveys is thus highly questionable. Further, the surveys were such that it was not possible to relate levels of malnutrition to other factors, particularly in the agriculture sector. This is a serious constraint as, although the treatment of seriously malnourished children is the primary responsibility of the Department of Health, any long term improvement in the nutritional status of young children generally will be more associated with interventions which improve the living standards of the majority of the population. In Papua New Guinea that means agricultural development, and it is essential that the results of national nutrition
surveys are related to the agricultural system. The two previous surveys used weight as the sole measurement of growth. Information already presented in this paper indicates that it is important to include length or height, as well as weight, as a primary measurement in the assessment of nutritional status.

In an attempt to improve the data on nutritional status throughout the country, a further national nutrition survey is currently being undertaken. The aims of the survey are to:

(a) provide reliable estimates of childhood malnutrition on a provincial basis;

(b) determine the extent to which the nutritional status of children varies with the physical environment;

(c) provide baseline data on the nutritional status of children against which to measure the effect of developmental programmes;

(d) assist government departments at both the provincial and the national level, and particularly the health and agriculture sectors, to use this information in planning departmental programmes.

A sampling frame based on physical environments was used for this survey, the target group for which is children under 5 years of age. The sampling frame was drawn up by the Division of Land Use Research of the Commonwealth Scientific and Industrial Research Organisation of Australia and the Land Utilisation Section of the Papua New Guinea Department of Primary Industry (Keig et al. 1992).

This project has identified a large number of different types of environments in Papua New Guinea, but for reasons of logistics and cost it was necessary to keep the environmental frame for the 1982-83 National Nutrition Survey relatively small. Those factors which have been used in the final classification are lithology and land form, relief, inundation, altitude and climate. The final product is a list of the census units falling within each environmental type for each province. Within each zone and within each province sampling is carried out on a cluster basis, a cluster being a census unit or combination of census units in areas where unit size is small.

A total of approximately 35,000 children will be measured throughout the country. Field work for this survey is being carried out by provincial staff drawn from many departments, but particularly from health and primary industry.

Analysis of the data is being carried out by the Institute of Medical Research and it is planned that the final analysis will be available in mid-1984.

The results of this survey will provide for the first time a comprehensive assessment of nutritional status across the whole country. It will then be possible to use this data to rank districts, provinces, and environmental zones within the country according to the nutritional status of the children found within them. The data will be useful for assigning priorities to the allocation of resources at both the
provincial and national level. In addition, the data will provide a baseline against which to measure the effect of economic development on growth.

More detailed nutrition surveillance will still be necessary in some areas and will be carried out either through special purpose surveys or through the routine activities of the MCH clinics of the Department of Health.

REFERENCES


situation, there is a more direct link between family or village food production and nutritional status than in urban populations. The types and ranges of food production on village land are directly related to the physical characteristics of the local environment (for example, landform, climate, soil). Environment broadly determines the crops that can be grown and the likelihood of seasonal food shortages and of catastrophic events such as frosts and drought, which affect food supply. Consequently, to gain an understanding of the variations in nutritional status in Papua New Guinea a knowledge of environmental characteristics and agricultural practices, as well as dietary patterns and nutrition, is required.

In 1981, a collaborative project was undertaken by the Department of Primary Industry (DPI) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) to assess the potential of the natural resources of Papua New Guinea for subsistence agriculture (food production), associated smallholder cash cropping and population growth. The project was described in a paper presented to the Second Food Crops Conference (McAlpine et al. 1982) and, with its emphasis on physical characteristics of land in relation to food production, it is directly relevant to considerations of food and nutrition issues in Papua New Guinea.

This paper briefly examines the development of recognition of the role of environment in the observed differences in nutritional status between different regions of the country. Investigations into the nature and strength of the links between environment and nutrition now form part of many nutrition surveys, and also of studies of agricultural practice and land use. The role of the joint DPI and CSIRO project in providing a sampling frame for the next national nutrition survey is discussed, and an outline is provided of the methods used. Early results from the project describe the distribution of population between different environments over the whole country. These results are discussed in terms of their relevance to both agriculture and nutrition in Papua New Guinea.

ENVIRONMENTAL CONSIDERATIONS IN PAST NUTRITION SURVEYS

The possibility that different environments might not provide equally well for the nutritional requirements of the rural populations living in them has long been recognised in Papua New Guinea. Over more than 30 years, many surveys conducted by health workers have compared the nutritional status of populations living in different regions of the country, where food consumption patterns are based on different staples. The first of these surveys, in 1947 (Hipsley and Clements 1950) compared nutrition in four villages representing the mainland coastal, inland and highland areas, and the islands. Marked differences in dietary intakes of calories, protein and other nutrients were reported between the different environments. Similar findings were subsequently reported in different areas of Papua New Guinea by Oomen (1958), Bailey (1963), Hipsley and Kirk (1965), in the epidemiological sample survey of Vines (1970), and by the International Biological Programme multi-disciplinary study of human adaptability (Harrison and Walsh 1974; Ferro-Luzzi et al. 1975, 1978). However, few attempts have been made in such studies to link dietary patterns with the
physical characteristics of particular environments and associated food production systems.

A singular contribution to the study of nutritional ecology in Papua New Guinea was made by Oomen (1970) who provided a description of the main types of subsistence diet found in different regions of the country, and discussed these in relation to local geographic and environmental factors such as climate, altitude, landscape, vegetation and distance from the coast.

Since then, a number of studies of rural food production systems have also included assessments of the nutritional status of the populations involved (for example, Bourke and Allen 1979; Allen et al. 1980; Spencer and Heywood 1983), but these have been studies of particular environments rather than comparisons between environments.

It is also possible to re-examine published data on nutritional status in different regions of the country in terms of possible environmental relationships. For example, a paper presented to the 1975 Papua New Guinea Food Crops Conference by Korte (1976) reports wide variation in malnutrition rates for children attending Maternal and Child Health (MCH) clinics in the different regions of the country. The lowest rates occurred in the New Guinea Islands Region, and the highest rates occurred in West Sepik Province. A table showing malnutrition rates for different areas of the Sepik Provinces was presented in Korte's (1976) paper (Table 1), but no suggestions were advanced to explain the observed pattern of variation. However, the variation in malnutrition rates followed the same pattern as would be predicted by a comparison of each environment in terms of its assessed potential for food production.

Table 1. **Percentage of children under-nourished attending MCH\(^1\) clinics in the Sepik Districts (reproduced from Korte 1976).**

<table>
<thead>
<tr>
<th>Location</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anguganak</td>
<td>72</td>
</tr>
<tr>
<td>Angoram Station</td>
<td>38</td>
</tr>
<tr>
<td>Angoram S.D.</td>
<td>56</td>
</tr>
<tr>
<td>Marienberg Station</td>
<td>46</td>
</tr>
<tr>
<td>Porapora</td>
<td>58</td>
</tr>
<tr>
<td>Aitape coastal</td>
<td>28</td>
</tr>
<tr>
<td>Aitape inland</td>
<td>78</td>
</tr>
</tbody>
</table>

\(^1\) Maternal and Child Health.
Thus, if we represent the environments as sections of a profile from the coast inland (Figure 1), the areas with the highest rates of malnutrition are distinguished by low fertility soils and an unsuitable climate for food cropping, and they have little or no access to fish as a protein supplement to the sago staple. By contrast, the areas with the lowest malnutrition rates were found on beach ridges, where food supplies are plentiful and varied. This type of environment can support very high population numbers. Although such an assessment of the data must be regarded as only one possible explanation of the cause of variation, it nevertheless encourages further attempts to examine in detail the relationships between nutritional status, diet, food production and environment.

In the past three years, a number of surveys conducted by nutritionists in different regions of Papua New Guinea have linked data on the nutritional status of children with data describing characteristics of the physical environment. Thus it has been possible to determine if statistically significant differences in nutritional status are in fact found between different environments. For instance in two surveys, one in Simbu Province (Harvey and Heywood 1983) and one in Menyamya District, Morobe Province (D. Leonard, personal communication), altitude was found to be significantly associated with nutritional status indices for children under five years of age. In Papua New Guinea, altitude can be regarded as a surrogate for temperature (McAlpine et al. 1983) and hence directly related to crop physiological requirements.

In Milne Bay Province, a survey was conducted by D. Leonard (personal communication) in which the villages were randomly selected from a sampling frame based on an environmental map of the Province prepared by Allen (personal communication) and derived from Blake et al. (1973) and Bleeker (1975). Results from the survey indicated that nutritional status indices for children living in coastal and riverine areas were significantly higher than those for children living further inland.

This survey was conducted as a pilot study for the then forthcoming National Nutrition Survey of Papua New Guinea. Following analysis of the results of the Milne Bay survey by W. Sampson (personal communication), the decision was made by an inter-Departmental Steering Committee that the National Nutrition Survey would adopt a sampling frame based upon the physical environment. The following section of this paper describes the methods which were used to provide a classification of all rural villages in Papua New Guinea by the main types of physical environment in which they are located. For the National Nutrition Survey, these environments were termed "ecological zones." A statistical sample of villages was selected from the sampling frame and children in these villages were surveyed in 1982-1983. The first results from the survey are now becoming available. A detailed description of the rationale, planning and execution of the National Nutrition Survey is provided by Heywood and Singleton (1983).
<table>
<thead>
<tr>
<th>Area</th>
<th>Porapora</th>
<th>Angoram</th>
<th>Anguganak</th>
<th>Aitape inland</th>
<th>Aitape coastal</th>
</tr>
</thead>
<tbody>
<tr>
<td>% children</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>under-nourished</td>
<td>58</td>
<td>56</td>
<td>72</td>
<td>78</td>
<td>29</td>
</tr>
<tr>
<td>Ecological zone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Riverine, seasonally inundated 0-600 m Humid</td>
<td>Hills and ranges sedimentary High relief 600-1200 m Perhumid</td>
<td>Hills &amp; ranges sedimentary High relief 600-1200 m Perhumid</td>
<td>Beach ridges 0-600 m Humid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food system</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sago plentiful</td>
<td></td>
<td></td>
<td>Sago cultivated</td>
<td>No fish Food gardens marginal</td>
<td>Sago available Food gardens adequate</td>
</tr>
</tbody>
</table>
The joint DPI and CSIRO project currently being undertaken in Papua New Guinea provides, for the first time, a national-scale delineation, definition and classification of all physical environments in the country, together with a complete list of the rural villages located within each environment and their resident populations. Consequently it is now possible to link nutritional survey data for any village with information on the physical characteristics of the environment in which that village is located and, by implication, with the type of food production system. Conversely, an environmental framework for nutritional studies and for other surveys of the rural population can now be provided.

The first stage of the project has involved the compilation and mapping of natural resource information for the whole of Papua New Guinea. Maps have been produced for each Province, in which the land area has been divided into a series of Resource Mapping Units (RMUs). Each RMU can be described in terms of a single combination of environmental parameters (for example, landform, altitude, rainfall and soil). The boundaries of the RMUs were determined by a change in any one of these parameters.

A microcomputer-based information system has been set up to store the environmental data for each RMU. This data base contains descriptions of some 4,600 RMUs over the whole of the country, and each RMU is described in terms of 60 different parameters.

In order to determine the population living within each RMU, the rural villages located within the RMU were identified by overlaying the mapped RMU boundaries on the census maps compiled at the time of the last National Census in 1980. These maps show the name, location and unique census unit number of every rural village in Papua New Guinea. Thus the census units located within the boundaries of each RMU could be identified, and this information has also been stored in the microcomputer data base. Resident population data for each census unit have been published by the National Statistical Office (1982) and these are also available in computer-readable form on magnetic tape. These data were linked with the census unit numbers for each RMU in the microcomputer system, allowing calculation of the total population living within each RMU. A sample page showing the environmental description for one RMU is presented in Figure 2.

This level of information was too extensive and too detailed to be used in its original form to provide the National Nutrition Survey sampling frame, as there was a requirement (resulting from logistic and financial constraints) that each Province should be divided into not more than about fifteen different ecological zones. An acceptable subset of the original data base was derived using only six environmental parameters to define a series of zones, each zone representing a different combination of these six parameters.
**Province 15 West Sepik**

**District 2 Vanimo**

**RMU No. 1**

**LAT. 2 Deg 37 min S**

**Long. 141 deg min E**

**Area 1 sq km**

---

**NATURAL RESOURCES**

**LANDFORM**
Raised coral reefs and associated back reef plains

**ROCKTYPE**
Limestone
Alluvial deposits

**SLOPE**
<2 degrees

**ALTITUDE**
0-600 m

**MAX TEMP**
32-30 degC

**MIN TEMP**
23-19 degC

**RAINFALL**
Annual
2500-3000 mm
Seas'lyty
100-200 to >200 mm
Deficit
Infrequent, slight deficit

**NATURAL RESOURCES**

**LANDFORM**
Raised coral reefs and associated back reef plains

**ROCKTYPE**
Limestone
Alluvial deposits

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**ALTITUDE**
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**MIN TEMP**
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Annual
2500-3000 mm
Seas'lyty
100-200 to >200 mm
Deficit
Infrequent, slight deficit

---

**SOIL**

**SOIL 1 Rendolls**

**STONINESS**
Not stony/rocky (<1%)

**DEPTH**
Moderately deep (50-100 cm)

**DRAINAGE**
Well-drained

**REACTION**
Strongly alkaline

**SALINITY**
None

**CATION EX**
Moder. (10-25 meq%)

**BASE SAT'N**
High (>0.5%)

**% N**
High (>0.5%)

**AVAIL P**
High (>20 ppm)

**EXCH K**
Moder. (0.2-0.6 meq%)

**ERODIBILITY**
Low

**AVAIL WATER CAPACITY**
0-25 cm Very low

**SOIL 2 Tropaquents**

**STONINESS**
Not stony/rocky (<1%)

**DEPTH**
Deep (>1m)

**DRAINAGE**
Poorly to very poorly drained

**REACTION**
Weakly acid to Neutral

**SALINITY**
None

**CATION EX**
Moderate (10-25 meq%)

**BASE SAT'N**
High (>60%)

**% N**
Moderate (0.2-0.5%)

**AVAIL P**
Moderate (10-20 ppm)

**EXCH K**
High (>0.6 meq%)

**ERODIBILITY**
Moderate

**AVAIL WATER CAPACITY**
0-25 cm Low

**SOIL 3 Trofluvents**

**STONINESS**
Not stony/rocky (<1%)

**DEPTH**
Deep (>1m)

**DRAINAGE**
Imperfection drained

**REACTION**
Acid

**SALINITY**
None

**CATION EX**
Moderate (25-50 meq%)

**BASE SAT'N**
High (>60%)

**% N**
Moderate (0.5-1.0%)

**AVAIL P**
Moderate (10-20 ppm)

**EXCH K**
Moderate (0.2-0.6 meq%)

**ERODIBILITY**
Moderate

**AVAIL WATER CAPACITY**
0-25 cm High

---

**Fitted Values**

**Population Density**
Total Population 335
Density on Total Area 335 persons/sq km
Density on "Used" Area 335 persons/sq km

**LAND USE INTENSITY**
sq km
Very low

**REGROWTH**
Mixture of tall and short woody

**NON-SUBSISTENCE USE**
Coconuts w/wo under-cropping

**SMALLHOLDER ECONOMIC ACTIVITY**

**DIST 2 VANIMO**

<table>
<thead>
<tr>
<th>Activity</th>
<th>No.</th>
<th>Total Activity No.</th>
<th>%Total</th>
</tr>
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<td>0</td>
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</tr>
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</tr>
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</tr>
<tr>
<td>rubber</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>c'not/crops</td>
<td>8</td>
<td>12</td>
<td>1</td>
</tr>
</tbody>
</table>

---

**Figure 2.** Sample environmental description for a Resource Mapping Unit (RMU No. 1) in West Sepik Province.
The parameters used were:

- landform;
- mean annual rainfall;
- altitude (surrogate for temperature);
- lithology;
- relief; and
- inundation.

The parameters landform, rainfall and altitude were regarded as "major" parameters which were included in descriptions of all ecological zones, while lithology, relief, and inundation were only included where they were necessary to further expand a particular landform description. For example, the inundation parameter was used to further subdivide the largest lowland landform class, which was "Riverine". Similarly, the landform class "Hills and Ranges", which describes approximately half of Papua New Guinea, has been subdivided by the use of lithology and relief to provide meaningful descriptions of particular environments.

In any Province, the population living within each ecological zone was determined by summing the populations of all census units within all RMUs classified as being part of that zone. A sample page of computer printout for West Sepik Province (Figure 3) lists a number of ecological zones, the RMUs within each of them, the rural villages (or census units) located within those RMUs, and the population of each village.

**POPULATION DISTRIBUTION BY ECOLOGICAL ZONES**

Population numbers within particular environments were totalled over all Provinces in Papua New Guinea in which those environments occurred. This provided, for the first time, accurate information on the distribution of population, in relation to environment on a nation-wide basis, which has direct relevance to any analysis of food production systems and nutrition.

The distribution of population in Papua New Guinea by landform type is shown in Figure 4. Most of the population (69 per cent) lives on steeplands which occupy 60 per cent of the total area of the country. Within these steeplands the majority of people live on land of higher rather than lower relief and slope, and there is also a strong tendency towards the use of volcanic and sedimentary landforms. The remaining 30 per cent of Papua New Guineans reside on relatively level terrain, the greater part of which is riverine, subject to inundation and sparsely populated. Although the remaining areas of level terrain, including raised coral reefs and beach ridges, are small in total area they are the most densely populated environments in the country as a whole. This is not to deny that particular areas of other environments are not also densely populated.

An analysis of population distribution in relation to mean annual rainfall (Figure 5) indicates that the population is distributed approximately in proportion to the area of each rainfall zone, except for the perhumid zone, which occupies 22 per cent of the total land area but supports only 10 per cent of the rural population.
<table>
<thead>
<tr>
<th>Landform</th>
<th>Lithology</th>
<th>Inundation</th>
<th>Relief</th>
<th>Altitude</th>
<th>Rainfall</th>
<th>RMU</th>
<th>DIST</th>
<th>CD</th>
<th>CU</th>
<th>Census Unit Name</th>
<th>Popn</th>
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<td>Humid</td>
<td>0-600 M</td>
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<td>51</td>
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| Coral Reef    | Humid     | 0-600 M    |        | 100      | 1        | 2     | 4   | 4  | TUMLEO ISLAND | 258  |
| Coral Reef    | Humid     | 0-600 M    |        | 101      | 1        | 2     | 1   | 1  | ALI ISLAND    | 365  |
| Coral Reef    | Humid     | 0-600 M    |        | 101      | 1        | 2     | 2   | 2  | ANGEL ISLAND  | 95   |
| Coral Reef    | Humid     | 0-600 M    |        | 101      | 1        | 2     | 3   | 3  | SELIO ISLAND  | 80   |
| Coral Reef    | Humid     | 0-600 M    |        | 1        | 2        | 5    | 4   | 4  | WUTUNG       | 335  |
| Coral Reef    | Humid     | 0-600 M    |        | 8        | 2        | 5    | 2   | 2  | VANIMO       | 560  |
| Coral Reef    | Humid     | 0-600 M    |        | 8        | 2        | 5    | 3   | 3  | WAROMO       | 518  |
| Coral Reef    | Humid     | 0-600 M    |        | 8        | 2        | 5    | 5   | 5  | YAKO         | 221  |

Figure 3. Sample page showing RMUs and Census Units within ecological zones in West Sepik Province.
Figure 4. Percentage distribution of total area and population by landform type.
Figure 5. Percentage distribution of total area and population by mean annual rainfall.
Two-thirds of the total area of the country is classified as humid, and within this zone is found 77 per cent of the rural population. Population distribution by altitudinal zone is shown in Figure 6. Lowland areas below an altitude of 600 metres above sea level (m asl) comprise two-thirds of the total land area of Papua New Guinea but support only 45 per cent of the rural village population. Intermediate altitudes between 600 m asl and 1200 m asl, which comprise 14 per cent of the land area, support only 8 per cent of the population. The greatest proportion of the population lives in highland areas between 1200 m asl and 2800 m asl; this region accounts for 17 per cent of the total land area but supports 46 per cent of the population.

DISCUSSION

The physical resource parameters used to delineate and classify the ecological zones are by no means the only factors which might contribute to differences in nutritional status between rural population groups in Papua New Guinea. Account must be taken of many social and economic factors related to food production systems, dietary intakes and nutrition. These factors include population density and growth rate, the proportion of land devoted to cash cropping and income therefrom, access to roads and markets, out-migration from rural to urban areas, morbidity (particularly due to malaria, intestinal parasites and infectious diseases), and cultural aspects of food preparation and distribution within the family unit. These latter factors are in a constant state of change during the development process, and their use to define a statistical sampling frame for rural surveys, including nutrition surveys, would therefore be inadvisable. However, those factors describing the physical environment will remain relatively unchanged over the time span of interest here.

Collection and analysis of nutrition survey data from a statistically-derived sample of all the major environments in Papua New Guinea will facilitate identification of those environments, and hence those food production systems, which are associated with the highest rates of malnutrition. Analysis of these results in terms of population distribution and environment will give an indication of levels of intensification of land use that could be associated with environmental deterioration (such as soil erosion and loss of soil fertility) and hence with malnutrition. This information on environment, population and nutritional status will enable nutritional, health and agricultural planning to focus on areas where the need is greatest for nutrition intervention and education programmes, for changes in the types and range of crops grown, and for improvements in farming practices.

ADDENDUM

The microcomputer-based information system referred to in this paper is known as the Papua New Guinea Resource Information System (PNGRIS). It is installed and in use at the Land Utilisation Section of the (now) Department of Agriculture and Livestock in Port Moresby. Detailed descriptions of the data compiled within PNGRIS and its microcomputer implementation can be found in Bellamy (1986) and Keig et al. (1987).
Figure 6. Percentage distribution of total area and population by altitude.
REFERENCES


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SEASONAL DIMENSIONS TO CHILD MALNUTRITION ON THE NEMBI PLATEAU SOUTHERN HIGHLANDS PROVINCE

Robert Crittenden¹ and Janis Baines²

¹Southern Highlands Rural Development Project, Mendi, Southern Highlands Province
²Nutrition Section, Department of Health, Mendi, Southern Highlands Province

ABSTRACT

Following work carried out by Bryant Allen and others into the causes of high rates of child malnutrition on the Nembi Plateau, a further study was carried out from October 1979 to March 1982. The investigation concentrated upon examining seasonal dimensions to malnutrition and its possible causes, by following the progress of forty children and their mothers for a complete agricultural cycle. Patterns of diets, disease, births, deaths, work loads and access to land were examined closely in one clan, which was then placed in the context of the Nembi Plateau by conducting a census and land-use study for the whole plateau. One thousand, one hundred and sixty two children under the age of five were measured in July to September 1980 to obtain an overall statement for the nutritional status of Nembi children.

Although seasonality in environmental factors in the Southern Highlands is not marked, there are distinct seasonal patterns in the work load of women, disease prevalence in the population, in the pattern of ceremonial and social activities, in births and deaths and in the growth performance of children born at different times of the year. The work loads of women as shown by the amount of land each had under sweet potato cultivation were very similar, and the simple model of equating nutritional status of vulnerable groups with food supply or productivity, as shown by area planted, was shown to be inadequate to explain the pattern of child malnutrition on the plateau.

Seasonal patterns of different factors impinging upon the well-being of the population were shown to be critical to a child's nutritional status. The root cause for such an interaction of seasonal patterns is thought to be a combination of the disturbance of a delicately poised agricultural system in a relatively harsh environment by European interference, and the destruction of traditional trade which has been used as a means of off-setting the disadvantages of a poor environment.
INTRODUCTION

In September 1978 a multidisciplinary team (Allen et al. 1978; Allen et al. 1980) set out to discover the possible causes of the high rate of malnutrition on the Nembi Plateau (Figure 1). The National Nutrition Survey of February 1978 had shown that of the 1281 children under the age of five measured (78 per cent of the child population of the plateau) 57 per cent were malnourished (below 80 percent weight-for-age).

Allen et al. (1978, 1980) concluded that the nutritional status of children on the Nembi Plateau was largely the outcome of factors internal to the plateau: high population densities, probably resulting from a gradual increase in population over a long period of time; and resulting soil degradation and low crop yields, placing ever increasing demands upon women who are responsible for producing the staple food, rearing pigs and bearing and caring for young children.

Taking as its starting point the conclusion of the 1978 survey that there is an "apparently strong circular relationship between low yields, low productivity, high female labour inputs and child malnutrition" (Allen et al. 1978:3 and 19) an eighteen month study was started in October 1979. Following that study, it was argued that the fundamental causes of the critical nature of child malnutrition are external to the plateau and of recent origin (Crittenden 1982).

The first cause is historical and is related to the sudden penetration of colonialism, unknowingly disrupting trade patterns critical to the plateau's economy. Pacification of the area also disrupted political processes, not only resulting in confusion relating to the role of men in society but also allowing migration back to the plateau of many refugee groups, thereby increasing population densities.

The second cause is related to the first and is a national development philosophy which condemns people occupying areas marginal for the introduction of the major export cash crop of the highlands, coffee, to remain relatively poverty stricken subsistence agriculturalists, while around them, in more favoured areas, people gain improved access to monetary wealth and consumer goods.

The third influence in the plateau is a subtle yet pervasive cycle of seasons which result from the movements of the inter-tropical convergence zone and the penetration of moist air masses into the Southern Highlands valleys during a period of predominantly south-easterly air movements. These air masses are blocked by mountain ranges to the south elsewhere in the highlands and periods of low rainfall are experienced. The result in the Southern Highlands is peculiar to that region in that there is a lack of overt seasonal contrast and rainfall is high all the year round (Fitzpatrick 1965: 67).

However, the socio-economy of the plateau exhibits seasonal fluctuations in labour inputs, food production, the pattern of births and birth-weights, deaths, illnesses and the onset of malnutrition among young children. This paper addresses the seasonal factors which combine to produce a seasonal pattern in the health of young children which recent events have made critical.
Figure 1. Map of Papua New Guinea showing the location of the Nembi plateau in Southern Highlands Province.
IDENTIFYING THE MALNOURISHED CHILD

During sixteen Maternal and Child Health (MCH) Clinic Patrols from Ol Health Sub-centre and Det Health Centre (See Figure 2) anthropometric data were collected for 1175 children of the Nembi Plateau (78 per cent of all children enrolled at the M.C.H. Clinics and 70 per cent of all children resident on the plateau in June 1980). The survey data set was reduced to 1162 cases as some of the children were already five years of age. The methods used were those described in Jelliffe (1966: 63-78) and the results were compared with those of Harvey (1979) for the Lagaip of Enga Province and of Hiles (1978) for the Kainantu region of the Eastern Highlands Province.

The survey showed that the growth path of Nembi children conforms to two general patterns of growth described for Highland Papua New Guinean children. Firstly the growth rates are well below Harvard Standards, and average weight-for-age, after the first six months of life, follows the 80 per cent growth path. Secondly, and which Allen et al. (1978, 1980) had also noticed, a sharp decline in status occurs between the age of six months and one year followed by a slight recovery between the 20th and 30th months of life. The decline in status (weight-for-age) of the Nembi child is more severe than children of Enga or Kainantu (Figure 3). Such a pattern is also evident in populations where nutritional and health status is quite good. Comparison of growth patterns in Simbu over the last 25 years demonstrates an overall improvement in growth performance during the period but, although average weights-for-age have increased, the pattern of growth remains similar (Harvey and Heywood 1983). Children between 6 and 18 months are still vulnerable.

The sharp decline in growth performance as shown by weight-for-age is reflected in a steady decline in height-for-age (Figure 4) and is also reflected in the proportion of children stunted, wasted, or stunted and wasted in the various age groups (Table 1). The proportion of children that is normal (Waterlow classification 1972, 1976) steadily declines as age increases with more children becoming stunted and with the majority of wasted, and stunted and wasted children in the two year age group.

THE FUNCTIONAL SIGNIFICANCE OF MALNUTRITION ON THE NEMBI PLATEAU

Data adequate for rigorous analysis of mortality rates are not available for the Nembi Plateau, although retrospective mortality interviews conducted by one of the authors (Baines 1983) do provide some information. One hundred women were interviewed from one clan pair (the Pubi - Penarop) in the Central Nembi Plateau and the results are shown in Table 2. The three time periods broadly correspond to the era before regular contact, the period of contact and consolidation with occasional health patrols in the area and the period since the opening of the Health Sub-centre at Ol. All mortality rates have declined over the period and the infant mortality rate has improved dramatically since the opening of the Health Sub-centre (see also Crittenden 1982: 346-347).
Figure 2. Map showing the Maternal and Child Health Clinics, and the Census Units of the Nembi Plateau and the Nembi Valley.
Figure 3. Graphs showing percentage weight-for-age of standard weight-for-age for children living on the Nembi Plateau, in Kainantu, and at Lagaip.
Figure 4. Graphs showing percentage height-for-age of standard height-for-age for children living on the Nembi Plateau, in Kainantu, and at Lagaip.
<table>
<thead>
<tr>
<th>Region</th>
<th>Age group (months)</th>
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<th>Stunted</th>
<th>Wasted</th>
<th>Stunted and wasted</th>
<th>Total number</th>
</tr>
</thead>
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<td>Number</td>
<td>Per cent</td>
<td>Number</td>
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Table 1.  

<table>
<thead>
<tr>
<th>Region</th>
<th>Age group (months)</th>
<th>Normal</th>
<th></th>
<th>Wasted</th>
<th></th>
<th>Stunted and wasted</th>
<th>Total number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Per cent</td>
<td>Number</td>
<td>Per cent</td>
<td>Number</td>
<td>Per cent</td>
<td>Number</td>
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<tr>
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<td>0</td>
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<tr>
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<td>41</td>
<td>42.3</td>
<td>30</td>
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<td>0</td>
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<tr>
<td>North</td>
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<td>45.7</td>
<td>43</td>
<td>54.3</td>
<td>51</td>
<td>0.0</td>
<td>0</td>
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<tr>
<td>Plateau</td>
<td></td>
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<td>104</td>
<td>48.8</td>
<td>100</td>
<td>0.0</td>
<td>0</td>
</tr>
</tbody>
</table>

1Stunted and wasted.
Most neo-natal deaths (deaths of children under the age of one month) occurred within 24 hours of birth (Baines 1983: 69). Diarrhoea was the main cause of infant death and diarrhoea and enteritis necroticans (pig-bel) the major causes of child deaths (Baines 1983: 69; Crittenden 1982: 354-355).

Direct correlation between death rates, nutritional status and disease prevalence is not possible from the data collected but it can be inferred that they are related. The sharp decline in growth performance after the first 6-8 months of life is the result of a number of factors subsumed under the term the "sucklings dilemma" (Waterlow 1981). The most important factors are the contamination of food by pathogens; the introduction of the child to a high bulk, low protein food supplement (Binns 1976); the growing inadequacy of breast-milk to supply a child's nutritional needs after six months of age; and the increasing risk of a child introducing pathogens into his mouth as his mobility develops (Biddulph 1973; World Health Organisation 1979: 133-150).

Prospective studies of child health in the Tari Basin (Smith 1978; Heywood 1982) have calculated the risk of death associated with poor growth performance. The Tari Basin is to the north of the Nembi Plateau and it is likely that a similar situation to Tari exists on the Nembi Plateau.

Children between 6 and 18 months in the Tari Basin below 65 per cent weight-for-age, or 85 per cent height-for-age, or 85 per cent weight-for-height, have a substantially higher risk of dying than children above those levels. It is therefore likely that malnutrition acting synergistically with childhood disease contributes substantially to the high child death rate on the Nembi Plateau. The question remains however of how to identify, other than from anthropometric measurements of survivors, children likely to suffer from malnutrition and consequently die.

Most surveillance systems identify those children already suffering from some degree of malnutrition and the associated risk of dying. What is needed is a system to identify children at risk before they become malnourished. Such a system requires a greater understanding of the factors contributing to child malnutrition and poor health. The following is an attempt to identify children most at risk in the age range 6 to 18 months on the Nembi Plateau.

### Table 2. Mortality rates on the Nembi Plateau from 1930 to 1980 (per 1000 live births)

<table>
<thead>
<tr>
<th>Period</th>
<th>Neo-natal</th>
<th>Infant</th>
<th>1-4 years</th>
<th>Child</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before 1950</td>
<td>56</td>
<td>155</td>
<td>141</td>
<td>296</td>
</tr>
<tr>
<td>1951-1970</td>
<td>72</td>
<td>160</td>
<td>77</td>
<td>238</td>
</tr>
<tr>
<td>1971-1980</td>
<td>40.5</td>
<td>55</td>
<td>81</td>
<td>162</td>
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</table>
CONTRIBUTORY FACTORS TO CHILD MALNUTRITION

The nutritional status of children in PNG is the outcome of their food intake, their environment and its prevailing economic and disease conditions and the quality of their maternal care (Oomen and Malcolm 1958: 3). Attempts have been made to link the nutritional status of children with ecological factors such as soils (IBRD 1978; unpublished data from the Tari Research Unit and the Institute of Medical Research) with little success. Jackson (1981) attempted to correlate socio-economic factors and productivity with nutritional status, but his methods and results are suspect (see Crittenden 1982: 272-300). More recent work in Simbu (Harvey and Heywood 1983), demonstrated the importance of factors such as access to services, access to cash income, and MCH enrollment, and the educational level of mothers, to the nutritional status of children. A feature of these attempts and others however is that the data used has been of a cross sectional nature. By using longitudinal data sets, the follow up survey on the Nembi Plateau isolated a number of factors that combine to render certain cohorts of children more vulnerable to malnutrition and death than others.

SEASONAL GROWTH PATTERNS ON THE NEMBI PLATEAU

Adopting the same methods used by Rowland (1981) in the Gambia, the growth paths of Nembi infants were examined to see if there were seasonal differences. The result is shown in Figure 5. It would appear that children born between August and January, although of a higher birth weight, perform less well than children born between February and July of a lower birth weight. Evidence from elsewhere suggests that the prevalence of low birth weight (LBW) is associated with high perinatal and neo-natal mortality rates and that LBW babies are more susceptible to infection and nutrient deficiencies affecting both post-natal growth and mental development (Hellier and Goldstein 1979; Chase 1969; Habicht et al. 1974; Morley 1973; Mata et al. 1975).

It is interesting to note that children of low birth weight on the Nembi Plateau appear to perform better than those that are heavier.

The available data (from January 1979 to January 1981) for birth weights of children born at the OI Health Sub-centre were examined (Baines 1983: 32-37) to see if the seasonal differences were significant for a larger sample. Tests were also carried out to see if the relative proportion of males to females born at different times of the year differed significantly and contributed to the observed differences in seasonal birth-weight.

The mean birth weight for males was 2892 g (standard deviation (SD) 418 g, n = 176) and for females 2750 g (SD 354 g, n = 146), the difference being very highly significant (p <0.001). A higher proportion of female births were of low birth weight (LBW 2500 g), 32.9 per cent compared to 22.7 per cent of male births; the difference was again significant (x² = 8.4, p <0.05).
Figure 5. Graphs showing the growth path of children for the first eight months of life born at different times of the year.
However there was no significant difference in the proportion of males to females born in each season. When the two seasons are subdivided into four then the seasonal pattern is clearer (Table 3).

A greater proportion of low birth weight children are born in the months of February, March and April than at other times of the year, which agrees with the pattern shown in Figure 5. However the heaviest babies are born in May, June and July with the smallest proportion of L.B.W. babies compared with other seasons. This tends to suggest that if adequate data were available then Figure 5 should be based upon four seasonal growth paths rather than two. Nevertheless the mean birth weights of children born between August and January is heavier than that between February and July (Table 3).

Tests were also carried out to see if the observed seasonal difference in birth weight was due to the proportion of births that were classed as Born Before Arrival (BBA), (BBA birth weights were very highly significantly lighter \( p<0.001 \)), or due to the distribution of birth weights according to the parity of the mother (first born babies were significantly lighter, and the percentage of them being LBW was significantly higher than babies of higher orders (Baines 1983: 32)). There were no significant differences in the distribution of BBA or parity which might account for the observed seasonal differences in birth weight. The conclusion drawn from the data is that there appears to be a seasonal pattern in birth weight on the plateau which is reinforced by a seasonal pattern in growth performance.

Table 3. Seasonal differences in birth weight of Nembi children, sexes combined.

<table>
<thead>
<tr>
<th>Months:</th>
<th>F.M.A.(^1)</th>
<th>M.J.J.</th>
<th>A.S.O.</th>
<th>N.D.J.</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>2500 g</td>
<td>24</td>
<td>15</td>
<td>21</td>
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<tr>
<td>2501-3000 g</td>
<td>24</td>
<td>32</td>
<td>39</td>
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<td>154</td>
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<tr>
<td>3000 g</td>
<td>15</td>
<td>22</td>
<td>18</td>
<td>25</td>
<td>80</td>
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<tr>
<td>TOTAL</td>
<td>63</td>
<td>69</td>
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<td>322</td>
</tr>
<tr>
<td>MEAN:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B.W.(^2) (g)</td>
<td>2734</td>
<td>2894(^3)</td>
<td>2833</td>
<td>2836</td>
<td>2828</td>
</tr>
<tr>
<td>S.D.(^4)</td>
<td>393</td>
<td>397</td>
<td>387</td>
<td>410</td>
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</tr>
<tr>
<td>LBW(^6) %</td>
<td>38.1</td>
<td>21.7</td>
<td>26.9</td>
<td>25.0</td>
<td>27.3</td>
</tr>
</tbody>
</table>

\(^1\)February, March and April. \(^2\)Birth weight. \(^3\)Highly significantly different \((p<0.01)\) from the mean birth weight for F.M.A. \(^4\)Standard deviation. \(^5\)Not available. \(^6\)Low birth weight.
Although the sample sizes in Figure 5 are small, the difference in growth performance for the first three months of life is significant. In the eighth month of life, the difference remains significant. Thus by fixing a seasonal time-scale to longitudinal growth data it is possible to subdivide into two groups children entering that period between the ages of 6-18 months, when they are likely to suffer from weaning stress. One group born between February and July, although of lower birth weight appears to thrive well by comparison with those born between August and January.

POSSIBLE EXPLANATIONS FOR THE SEASONAL PATTERNS OF BIRTH WEIGHT AND GROWTH PERFORMANCE OF NEMBI PLATEAU CHILDREN

Although children more vulnerable to poor health and nutritional status than others of the same age have been identified the causative agents are difficult to isolate. However the longitudinal monitoring of other factors does provide some clues that need to be followed up. Factors such as the seasonal pattern of diseases, deaths and births were monitored and extracted from Ol Health Sub-centre records. Mothers were questioned as to their work activity throughout one gardening cycle and their weights monitored. Diets of pregnant women, their weight gain, and their haemoglobin levels were also recorded monthly and the diets of children under the age of five were monitored monthly.

Disease and Death and the Pattern of Births

The seasonal pattern of disease as shown by all inpatients recorded at Ol Health Sub-centre are shown in Figure 6. The major killers of infants and toddlers on the Nembi Plateau are diarrhoea and other gastro-intestinal complaints (16 per cent of infant deaths), viral diseases (9 per cent) notably measles, malaria (4 per cent) and respiratory disease (14 per cent). Malnutrition was only recorded in 5 per cent of cases as the direct cause of death although, no doubt, poor nourishment contributed to the other categories as well. The seasonal pattern of child death is shown in Figure 7.

From February to July appears to be the most hazardous period for young children, and those children born between August and January and thus being introduced to solid foods in the period February to July, are especially vulnerable.

The seasonal pattern of births shown in Figure 9 shows that more children are born between August and February thus exacerbating the significance of the period from February to July for death of weanlings. That this pattern does not occur every year is shown in Figure 8 where a four yearly cycle is apparent. An attempt at explaining this has already been made (Crittenden 1982: 358-367); it is probably related to garden and fertility rituals.
Figure 6. Graphs showing the seasonal pattern of disease as shown by in-patients recorded at Ol Health Sub-centre (1975-1980).
Figure 7. The seasonal pattern of child deaths (0-5 years old) and inpatients at Ol Health Sub-centre (1975-1980).
Figure 8. Graphs showing the seasonal pattern of births in the Yoel el (Pubi-Penarop, Endusparr, Murupa, Porelep and Epityokul).
Women's Work Activity and Diets

Baines (1983: 1-9) has already provided a summary of the factors that influence birth weight, and not the least are those that influence maternal weight gain during pregnancy, notably work activity and diet. Seasonal patterns in these factors were observed on the Nembi Plateau. February to July was a period of good food availability while August to January was a period of relative food shortage. Results from a market survey (d'Souza 1982) conducted from September 1978 to August 1981 provided evidence for a seasonal supply of food on the Nembi Plateau, and analysis of maternal diets (Baines 1983: 53-58) and of children's diets (Crittenden 1982: 441-542) showed a similar pattern. The seasonal pattern for the consumption of greens and leafy vegetables by children was most marked (Figure 10 and Figure 11). It showed that children who began to eat solids from May to October were disadvantaged, a disadvantage most keenly felt by those born between August and January, who were already suffering from the effects of a higher disease prevalence slightly earlier in the year.

We tentatively suggest here that the seasonal pattern of food availability also affects maternal weight gain and birth weight, although the data are far from adequate to demonstrate this (Crittenden 1982: 405-407; Baines 1983: 63-68). In any case it appeared from the Nembi data that children of low birth weight, if born between February and July were not seriously disadvantaged because of it (Figure 5). The pattern of poor child growth performance is more likely to be linked to the standard of maternal care, the activity of the mother, and to the prevalence of disease at particular times of the year. This may also affect the weight gain of pregnant women.

The activities of women are shown in Figure 12 and Figure 13. The seasonal activity in the gardens is immediately apparent, especially in the cultivation of sweet potato. Preparation of new mounds and planting, the most strenuous of activities for women, took place from October to February, which was also the time when the majority of mixed gardens were prepared and planted. The seasonal pattern of food availability and consumption reflected the seasonal planting cycle.

The activity of women was also reflected in the percentage of women losing weight or not gaining weight in any one month relative to the previous month, which was highest for the period from September to January. The differences in absolute weights were not significant and more research is needed to test the relationship between workload of women, energy expenditure and their health status and weight. Factors such as the age of the woman, the number of children she has had, her menstrual state at the time of weighing, and whether weighed in the morning or evening, and whether before or after a meal would have to be taken into account. A functionally significant weight loss would have to be defined and distinguished from normal weight fluctuations.
Figure 9. Histogram showing the cyclical and seasonal patterns of birth at Embi and Enip Maternal and Child Health clinic catchments (Pubi-Penarop, Porelep, Murupa and Werut-Marop clans) recorded at Ol Health Sub-centre from 1971 to 1980.
Figure 10. Histograms showing the seasonal consumption of *Rungia klossii*, pumpkin tops and nine other types of green leafy vegetables by Pubi children.
Figure 11. Histograms showing the seasonal consumption of various types of beans by Pubi people.
Figure 12. Graphs showing the seasonal activities of Pubi women from April 1980 to February 1981.
Figure 13. Graphs showing the seasonal activities of 29 Pubi women in sweet potato gardens from April 1980 to February 1981.
Nevertheless the picture does fit the seasonal pattern of birth weights and the seasonal pattern of growth of infants already described. The low mean birth weight of infants born between February and April may reflect the hard work in the gardens undertaken by women from November to January. At this time energy expenditures are probably higher than at other times of the year and food intakes are lowest (Baines 1983: 51-58). In the last trimester of pregnancy low maternal food intake has the most influence on birth-weight.

**DISCUSSION: THE SEASONAL PATTERN OF GROWTH OF CHILDREN ON THE NEMBI PLATEAU**

The work of women during the mixed garden season from November to January is critical to understanding the growth patterns of young children. In combination with the seasonal prevalence of disease and food availability, the seasonal nature of the socio-economy of the Nembi Plateau renders certain children more vulnerable than others to the risk of malnutrition, poor health and death (Figure 14).

For children born between August and January, despite their higher mean birth weight, the risk of malnutrition is higher since the introduction of solid foods, a period of psychological as well as physiological stress, coincides with the period when the mother’s activity is greatest and food availability is lowest. It is immediately followed by a period of high disease prevalence.

These factors influence a mother’s ability to care for her child, as well as the child’s health status. The high number of child deaths in the period from March to June reflects this pattern. Child deaths in this period include neo-natal deaths of children born between February and April when birthweights are low. The period also includes infant deaths from diarrhoea and pneumonia, especially of those born between August and January, and introduced to solids from November to April, and child deaths following a period of low food intakes (August - January) and exposure to malaria, diarrhoea and other gastric complaints (November - May).

Children born between February and July are fortunate in that their mothers have food available for them and are not working strenuously in the gardens. They therefore thrive, despite their low mean birth weight. Because they are being breast-fed they are not exposed to the risk of infection from contaminated food, and this, coupled with the immunity advantages of breast-fed children, helps to protect them at a time of year when the risk of contracting diarrhoeal disease is high. By the time their mothers again undergo stress from food shortages and hard work in the gardens, the child born between February and July has a better health status and is more able to cope.

**CONCLUSIONS AND RECOMMENDATIONS**

The causes of the seasonal patterns of the plateau are related to physical as well as socio-economic factors. Evidence has been presented (Crittenden 1983: 376-440)
to suggest that the socio-economic seasonal patterns, especially in birth patterns and garden activity are linked ritually and are a logical response to physical conditions to the environment. Given the immutability of the environment, recommendations must address changes in peoples' attitudes and behaviour, and provide them with the wherewithal to readjust to the environment in which they live, reducing the effects of seasonality as a critical factor.

There are seven main conclusions, as listed below.

1. More research is needed to study the longitudinal patterns of factors affecting birth weight and growth performance of children. At present, MCH data from the Southern Highlands Province are being analysed for any seasonal patterns in growth performance. Such factors would include women's activities, energy expenditure and intake during pregnancy and subsequent birthweights.

2. Reduction of workload and increase in productivity: an immediate and relatively inexpensive improvement would be the provision of spades/hoes to replace the digging sticks normally used by women for all garden tasks. Women have also been encouraged (by governments and missions) in the past to plant mixed gardens throughout the year. Although this would improve diets, the risk of insect infestation or low rainfall is high at particular times of the year and many women do not consider the effort of continual preparation of gardens worthwhile. Improved, higher yielding varieties of sweet potato would raise the marginal productivity of women's work effort. Introduced varieties of greens, peanuts and beans as well as small animals would also improve diets.

3. Improvement of soil fertility: experiments have been carried out to find ways to increase soil fertility on the plateau (d'Souza 1982) but many improvements, such as manuring, would initially increase the workload of women, which may not be possible if they are already working at their limit.

4. Reduction of disease: the incidence of malaria might be reduced by extending the existing eradication programme to cover the whole of the Plateau. A regular supply of common drugs (for example, to treat worm infestation) at the Health Sub-centre would be valuable. A reduction in the incidence of disease is also related to the next recommendation.

5. Improvement of living standards: a source of clean water in the village or hamlet would reduce the energy expended to collect the water as well as improve its quality and make water available for washing food, clothes and for personal hygiene. At present, water is scarce and used sparingly, despite the fact that rain falls virtually every day. The increased use of latrines would improve sanitation and reduce the incidence of environmental diseases.

6. Access to cash income: there are little data on cash available to households or to women within households. More research in this area is needed, but
given the evidence from Simbu (Harvey and Heywood 1983), increased cash earning opportunities are likely to raise living standards and the health of women and children.

7. Long term changes of responsibility: improvements of women's intakes and of children's birthweights will not occur by improving diets alone. In the long term it would obviously be beneficial to the women if some of their work was shared by males. However, the division of male and female roles is traditional within each area of PNG and such changes can obviously only be made by the people of the Nembi themselves, and will occur only if they see a good reason to change.

Work is still needed to ascertain the causes of poor health and nutrition in many parts of Papua New Guinea. All too often research and intervention programmes have only looked at parts of the problem. There is an urgent need for research of a multidisciplinary nature to integrate the medical, agricultural and social sciences. The question of seasonality would appear to be a good framework for research of this nature and the temporal dimension will not only aid in identifying groups most in need but also, through better understanding of the processes taking place, point to appropriate interventions.

REFERENCES


