Improving yield and economic viability of peanut production in Papua New Guinea and Australia

Proceedings of a workshop held in Lae, Papua New Guinea, 18–19 October 2005

Editors: Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna

Australian Centre for International Agricultural Research
Canberra 2006

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

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

Where trade names are used this constitutes neither endorsement of nor discrimination against any product by the Centre.

ACIAR PROCEEDINGS

This series of publications includes the full proceedings of research workshops or symposia organised or supported by ACIAR. Numbers in this series are distributed internationally to selected individuals and scientific institutions.

Rachaputi, Rao C.N., Wright, G.C., Kuniata, L. and Ramakrishna, A., ed. 2006. Improving yield and economic viability of peanut production in Papua New Guinea and Australia. Proceedings of a workshop held in Lae, Papua New Guinea, 18–19 October 2005, Canberra. ACIAR Proceedings No. 122, 124p.

ISBN 1 86320 466 3 (print)
1 86320 467 9 (online)

Typesetting and layout: Sunset Digital Pty Ltd, Brisbane, Australia
Printing: Elect Printing

Contents

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

Foreword

Peanuts are an important cash crop for many smallholder farmers in Papua New Guinea (PNG). The area planted to peanuts is expanding at smallholder level and substantial areas of commercial production are also being planted which should lead to significant expansion of the industry over the next five years.

The project whose results are recorded in this publication is an important one, kick-starting the re-emergence of a peanut industry in the Markham Valley based on seed and product quality, private sector involvement, production at two levels (estate and smallholder) and indigenous leadership of a high calibre.

These proceedings include the results of two important industry surveys conducted on peanuts in PNG — a survey of peanut farmers and a survey of aflatoxin contamination in domestic peanuts and peanut products sold at roadside markets. The former survey revealed the pervasiveness of peanuts in smallholder agriculture in PNG, while the latter survey revealed very high levels of aflatoxin in up to five per cent of the samples.

Introduction and evaluation of new varieties was a key focus of the project, with two- to three-fold improvements in yields of introduced varieties over existing varieties being achieved in research plots.

The use of crop modelling in this project appears promising and should prove a valuable tool in providing advice on what variety to grow, where and when, probability of yield and preharvest aflatoxin risk, in the context of likely expansion of peanut production into a range of agro-ecological zones of varying climatic constraints in both PNG and Australia. This will be particularly useful in the expansion of the industry into new areas.

These proceedings also include a description of the ‘Smartpeanut’ economic modelling software package, which can assist peanut growers and consultants by predicting economic performance of the whole farm under various cropping and economic management scenarios.

The ‘Smartpeanut’ program will also be a useful research tool for farming systems researchers as it can enable study of the impacts of climate and agronomic practices on farm sustainability and profits. This will be particularly useful in the expansion of the industry into new areas in both PNG and Australia.

The results reported in this publication provide a good base for a further project which ACIAR is supporting. The papers contained in these proceedings were presented at a workshop in Lae and provide a valuable resource for both researchers and extension workers in the peanut industry.

Peter Core
Director
Australian Centre for International Agricultural Research

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

The peanut project team inspecting a varietal trial on a farmer's field at Kainantu, Papua New Guinea

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

Introduction and welcome

Brown Bai CBE, Member of the Australian Centre for International Agricultural Research Policy Advisory Council

I am greatly honored to accept your invitation to join you in this Final Review Workshop of the ACIAR Project ASEM/2001/055, *Improving yield and economic viability of peanut production in Papua New Guinea and Australia using integrated management and modelling approaches*.

On behalf of the ACIAR Policy Advisory Council, let me congratulate all of you for your effort in executing the various work programs that constitute this project. This workshop will continue to review the work done so far and determine how best we should move forward with the next phase of the project. The current project commenced in 2001 and ran until June 2005 and was extended to December 2005.

This project and its outcomes are very important for Papua New Guinea (PNG), particularly in addressing how peanuts can be developed into a commercial and vibrant industry, which will benefit the small farmers in the villages and the big commercial corporate industries.

We all know that peanut is grown and sold by thousands of farmers throughout PNG. It is a source of revenue and food for the small farmers. Yet, we do not know the exact amount that is produced, consumed and traded.

We also know that peanut is a potential export commodity which can generate significant revenue for the country. It can also be processed into peanut butter for the domestic and export markets. Peanut hay is used in the livestock industry as stockfeed. In that situation, it contributes to the promotion of the growth of the livestock industry and can save huge import bills.

For us to realise these enormous contributions, we are challenged to do more research to find the most economical and feasible way to develop this industry. The outcome of this project will be assessed and judged very seriously.

When ACIAR first became involved in this project in 2001, it recognised that the project will ultimately generate the basis for developing a peanut industry which will greatly enhance the income capacity of small farmers and the country. This expectation is clearly reflected in the aim of the project, which is to improve yield, quality and/or peanut production in PNG and Australia.

I want to thank the Australian Government for its continued support for the development of the agriculture sector, by supporting the work of ACIAR in PNG. Today ACIAR is involved in funding about 35 active bilateral projects in PNG worth over A$3.1 million. All these projects are directly aimed at improving the overall income and general welfare of PNG and its population.

Agriculture directly benefits the 4.3 million people who live across the rural face of this massive country. Every bit of help that can be injected into the development of the agricultural sector significantly promotes the standard of living of the majority of PNG's population.

I would like to call on all leaders in the national government, provincial governments, private sector and non-government organisations to work together to develop the agricultural sector. It is necessary for provincial governments to develop provincial agriculture plans which must commit them to the development of agriculture in their respective provinces. After all, this is the only way to implement the Medium Term Development Strategy and the government's Green Revolution Policy.

In 2004, the agricultural sector alone accounted for nearly K1.9 billion of the total PNG export value of K8.2 billion from existing agricultural export commodities. An improving and vibrant agricultural sector provides the country with a platform to carry forth a sustainable form of development where every person in this country is benefiting.

PNG must promote and maintain a constructive, consistent and innovative attitude to development. We must do more research so that we can carefully and sustainably exploit all the natural resources that we are so richly blessed with and can thus convert this country from the land of unexpected, to the land of expected and prosperity.

Financial support that we secure from ACIAR and other international agencies will assist us in this pursuit. PNG's destiny belongs to PNG and only PNG can make that difference.

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

Improving yield and economic viability of peanut production in Papua New Guinea and Australia using integrated management and modelling approaches — overview of ACIAR project ASEM 2001/055

Rao C.N. Rachaputi

Department of Primary Industries and Fisheries, PO Box 23, Kingaroy, Queensland 4610, Australia; email: rao.rachaputi@dpi.qld.gov.au

ACIAR project ASEM 2001/055 was commissioned in July 2002 by the Queensland Department of Primary Industries and Fisheries (DPI&F) in collaboration with the National Agricultural Research Institute (NARI) and Trukai Industries Ltd in Papua New Guinea (PNG), with a major aim of improving yield, quality and economic viability of peanut production in PNG and Australia. In year 2, Ramu Sugar Ltd, a private R&D agency, was formally included as a collaborator in the project.

Peanut production in PNG, which was an important industry, has declined from 2500 t in the 1960s to <1000 t in the 1990s for a number of reasons including lack of access to improved high yielding varieties, inappropriate agronomic practices and inconsistent market demand. While commercial production for processing and export has ceased since the late 1980s, production for subsistence use and for urban and roadside markets has probably increased. When the project started there was very little

Dr Lastus Kunitia and Maria Linibi examining a peanut farmer's field at Mutszing, Papua New Guinea

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

NARI and Department of Agriculture and Livestock staff inspecting a peanut trial at Sepiga village, near Goroka in the Eastern Highlands of Papua New Guinea

information about peanut production, utilisation and aflatoxin risk.

The peanut industry in Australia is much more developed than the PNG industry, however some constraints such as drought and aflatoxin are common issues for the industries in both countries. Discussions at several peanut grower group meetings in Queensland have revealed the need for an economic decision support package to assist peanut growers in making critical decisions about farm management and financial planning based on both long-term scenario analysis as well as in-season crop risk monitoring. A biophysical peanut model in the Agricultural Production Systems Simulator (APSIM) model and derived software packages such as Whopper Cropper are addressing crop production risks but these do not incorporate farm economic risks associated with peanut production systems. One of the major objectives of the project was the development of a farm economics management software tool which combines the currently available biophysical models with whole farm economics models.

Given the diverse needs of the peanut industry in Australia and PNG, the major objectives of the project were:

1. To generate information on peanut production, post-harvest storage, utilisation, marketing systems and extent of aflatoxin contamination in the major peanut production regions of PNG.
2. To use a crop-modelling approach and field experiments to develop and implement improved varietal and management approaches for economically sustainable peanut production.
3. To develop a farm economic management software package to provide the Australian peanut industry with improved capacity to explore economic consequences associated with production and resource management risk in peanut farming systems.

Although the project faced a few problems initially due to frequent staff changes in NARI, communication issues between Australian and PNG project teams, and data management, the situation improved significantly in years 2 and 3, resulting in the project objectives being achieved.

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

Table 1 presents the progress made in the project against the expected outputs under each of the objectives.

In addition to the outcomes listed in Table 1, the following training and capacity building activities were accomplished in the project:

- An automatic weather station was assembled and installed at the Cleanwater farm (Trukai managed) to record air, soil temperatures and solar radiation
- A mini-column facility for aflatoxin analysis was installed at the NARI chemistry laboratory, and Mime Saine, a technician at the laboratory, was trained in procedures for aflatoxin analysis

Table 1. Progress made against project objectives

Objective 1. To generate information on peanut production, post-harvest storage, utilisation, marketing systems and extent of aflatoxin contamination in the major peanut production regions of Papua New Guinea.	
Expected outputs	**Delivered outcomes**
1.1. A detailed assessment of the status of peanut production, delivery channels, market system and utilisation in major peanut growing regions in Papua New Guinea	A survey of farmers from four major peanut production regions i.e. Morobe, Eastern Highlands, East New Britain provinces and National Capital District was conducted and a comprehensive report published by NARI in October 2004 (see p. 6 in the proceedings for summary of the survey).
1.2. Assessment of the extent of aflatoxin contamination at the major market outlets.	An aflatoxin survey was implemented in which about 274 peanut samples were collected from major roadside markets and analysed for aflatoxin content (see Rachaputi et al. p. 17, these proceedings).
1.3. Publicising of the findings to government and private research and extension agencies	The results from the aflatoxin survey were also presented at an international medical symposium in Goroka. A comprehensive report of the aflatoxin survey is published in these proceedings (p. 17). The aflatoxin activity in the project led to initiation of an Agricultural Innovations Grant Facility-funded aflatoxin awareness project.
Objective 2. To use a crop-modelling approach and field experiments to develop and implement improved varietal and management approaches for economically sustainable peanut production.	
2.1. Characterisation of major peanut growing environments using a crop modelling approach.	APSIM peanut model validated for Aiyura, Bubia and Ramu Sugar sites Long-term climate data records assembled and used with the peanut model to assess yield and aflatoxin scenarios for Aiyura, Bubia and Ramu Sugar sites (see Chuhan et al. p. 68, in these proceedings)
2.2. Identification of promising varieties with high yield and local market requirements.	Improved peanut germplasm introduced from ICRISAT, evaluated and promising varieties identified
2.3. Cost-effective management practices to achieve high yield and quality.	Information on the effects of plant densities, seed dressing, fertilisers, pest control and peanut storage was generated.
2.4. Integrated varietal management package for adoption by progressive farmers.	Preliminary on-farm trials on integrated varietal and management packages were initiated in the extension phase of the project.
Objective 3. To develop a farm economic management software package to provide the Australian peanut industry with improved capacity to explore economic consequences associated with production and resource management risk in peanut farming systems.	
3.1. An interactive decision support package to assess potential opportunities and economic risks associated with sustainability of irrigated and dryland peanut farming systems.	A 'beta' version of the economic modelling software package 'Smartpeanut' has been developed and is being evaluated by peanut growers, agronomists and processors in Australia (see p. 79 in these proceedings).

Dr Ramakrishna, NARI, showing a promising peanut variety

- The following training visits were organised for PNG collaborators in Australia:
  - Johnny Wemin and Humphrey Saese undertook a 2-week training visit (on peanut research techniques, agronomy and data management) at DPI&F Kingaroy (29 March–9 April 2004)
  - Yanding Tomda and Timothy Geob undertook a 2-week training visit (on peanut research techniques, weather and crop data management, and application of the peanut crop model) at DPI&F Kingaroy (4–20 April 05)
- Monitoring visits were conducted by the QDPI/ICRISAT team to inspect the field trials and participate in planing and review meetings in PNG.

In addition to annual planning and review meetings, the project team members in PNG met at regular intervals to exchange information on project related activities.

The project was reviewed by an external review team (Drs Mal Hunter and James Kaiulo) in October 2004. After assessing the external review report, ACIAR

(i) approved a project variation and extension proposal to address some selected recommendations of the ACIAR review in the current phase of the project and initiate the most important activities of the new project in a 6-month extension phase of the current project (i.e. to December 2005), and

(ii) recommended that DPI&F, in consultation with the PNG collaborating agencies, develop a proposal for a new project to commence 1 January 2006, as per the external review recommendation. (The new project proposal is in the final stages of approval at the time of compiling these proceedings.)

These proceedings also report on the progress made in the extension phase of the current project and summarise the new project proposal ASEM 2004/041 on 'Productivity and marketing enhancement for peanut in Papua New Guinea and Australia'.

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

Production, processing, consumption and utilisation of peanut in Papua New Guinea — a survey of peanut growers

Johnny M. Wemin[1], A. Ramakrishna[1], Timothy Geob[1] and Rao C.N. Rachaputi[2]

[1]*National Agricultural Research Institute, Aiyura, Papua New Guinea; email: a.ramakrishna@nari.org.pg*

[2]*Department of Primary Industries and Fisheries, PO Box 23, Kingaroy, Queensland 4610, Australia.*

Abstract

The National Agricultural Research Institute (NARI) conducted a survey of peanut farmers in four provinces representing the different regional and agro-ecological zones in Papua New Guinea (PNG) between March and May 2003. The survey was part of a three-year collaborative research project with the Australian Centre for International Agricultural Research (ACIAR), the Queensland Department of Primary Industries and Fisheries, Trukai Industries Ltd (PNG) and Ramu Sugar Ltd (PNG) to improve the yield, quality and economic viability of peanut production in PNG and Australia. The objective was to generate information on peanut production, post-harvest storage, utilisation, marketing systems and the extent of aflatoxin contamination in peanut growing regions of PNG. Eastern Highlands Province (Highlands Region), Markham Valley (Dry Lowlands), National Capital District (Dry Lowlands and Peri-Urban) and East New Britain Province (Wet Lowlands) were selected for the survey, based on NARI's agro-ecological zoning, socioeconomic classification and the importance of peanut in the farming system.

The survey, which involved a pre-tested questionnaire and semi-structured group and individual interviews with the growers, covered a total of 16 villages or settlements and 64 households and farms.

The survey revealed that peanuts play a significant role in increasing individual household incomes, thus contributing to improvement in living standards in all the surveyed provinces. Peanut ranked amongst the top five crops across all regions for generating income. It is estimated that about 60% of PNG farming families or households in the survey areas grew peanuts covering an estimated land area of 14,000 hectares. The production estimate of 12,600 tonnes of peanut pods earned a gross income of K29,359,000. An estimated gross margin of K960 per hectare is equivalent to US$290/ha or A$390/ha.

Women, in particular, especially in the highlands, played a major role in utilising peanut crops for income generation. The survey identified several key constraints for peanut production and marketing in PNG.

Introduction

Production, utilisation and marketing of peanuts *(Arachis hypogaea)* in Papua New Guinea (PNG) dates back to the early European and missionary contacts. The farmers enjoyed direct export market price through the colonial administration. In the East New Britain Province, the oldest person recalled the first seed supply in the 1930s. Peanuts certainly remain an important cash crop among settlers, peri-urban gardeners and remote villagers. Farmers in remote villages appreciate peanuts as a lighter crop to transport to the markets compared to other bulky and highly perishable vegetables such as sweet potato *(Ipomoea batatas)*, English potato *(Solanum tuberosum)*, banana *(Musa* spp.), yam *(Dioscorea* spp.), taro *(Colocasia esculenta)*, cabbage *(Brassica oleracea)* and tomato *(Lycopersicum esculentum)*. Peanuts generate a major portion of the family income in the highlands where coffee *(Coffea arabica)* is the major cash crop.

Women in particular recognise the potential of the crop and devote much time and effort to the production and marketing of peanuts. Nearly all peanuts produced in PNG are consumed domestically as food and they represent an important part of the diet by providing a rich source of protein, oil and vitamins, especially for the poorer sections of the community. Peanut contains 25–30% high quality protein, 46–50% oil and provides an inexpensive, high-protein, high energy food for humans and livestock.

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

However, significant volumes of peanut products (such as blanched, roasted nuts, peanut butter and oil) are also imported for sale in supermarkets for consumption by the urban population, suggesting there is good scope for expansion of domestic production and processing to replace imports.

The PNG population is presently growing at a mean annual rate of 2.3% (Keig 1999), with more than 75% of the total population (about 4 million people) being smallholder semi-subsistence farmers, sustained by their own food production systems, supported by some cash crops (Allen et al. 1995). While population growth is significant, there has been little expansion of agricultural land (McAlpine et al. 2001), which implies significant intensification of agriculture within existing cropping areas. Although it was obvious that peanuts are playing an important role in crop intensification in various production systems, there is little information about the status of, and constraints to, peanut production, utilisation and marketing systems in PNG. It is highly likely that the production and demand for peanut will increase with growing population and intensification of agriculture. However, in order to enhance productivity and marketability in a sustainable manner, it is necessary to understand the status of and constraints to peanut production and marketing.

As part of the ACIAR project (ASEM 2001/055), NARI conducted a survey of peanut farmers during March–May 2003, in four major peanut production regions in the country. The major aim of the survey was to generate information on peanut production, post-harvest storage, utilisation, marketing systems and extent of aflatoxin contamination in the peanut growing regions of PNG. A comprehensive report of the survey has been published by NARI (Wemin and Geob 2004). This paper presents the main findings of the peanut farmer survey.

Methods

Survey sites

The survey sites were selected according to NARI's agro-ecological zoning, socioeconomic classification and the importance of peanut in the farming system. Eastern Highlands Province (highlands region), Markham Valley (dry lowlands), National Capital District (dry lowlands and peri-urban) and East New Britain Province (wet lowlands) were selected based on the above criteria. The target population at each survey site consisted of farmers in the different regional and agro-ecological zones of PNG. Accordingly, four villages or settlements in each of Eastern Highlands, Markham Valley, National Capital District and East New Britain were randomly selected for the surveys (Table 1). Villages with limited access and strife problems were omitted.

Survey team

A multidisciplinary team of 2–6 interviewers consisting of scientists, technical officers, and information and outreach officers from the National Agricultural Research Institute (NARI) and volunteers from the non-government organisations (HOPE, World Wide

Table 1. Survey sites in the major peanut growing regions of Papua New Guinea

Village	District	Province/ region	Agro-ecological zone	Socioeconomic status
Samogoyufa	Goroka	Eastern Highlands Province	Highlands	Rural
Korofeigu	Unggai-Bena	Eastern Highlands Province	Highlands	Rural
Sikenafamo	Henganofi	Eastern Highlands Province	Highlands	Rural
Ikana	Obura-Wonenara	Eastern Highlands Province	Highlands	Rural
Mampim	Markham	Morobe	Dry lowlands	Rural
Sirasira	Markham	Morobe	Wet lowlands	Rural
Zafasing (40 mile)	Markham	Morobe	Dry lowlands	Rural
Naraguam (Yalu)	Huon Gulf	Morobe	Wet lowlands	Peri-urban
9 mile/Makana	North East	National Capital District	Dry lowlands	Peri-urban
Erima/Wildlife	North East	National Capital District	Dry lowlands	Peri-urban
6 mile Dump	South	National Capital District	Dry lowlands	Peri-urban
Gerehu	North West	National Capital District	Dry lowlands	Peri-urban
Rabagi No. 2	Kokopo	East New Britain Province	Wet lowlands	Rural
Malasaet	Pomio	East New Britain Province	Wet lowlands	Rural
Navunaram	Gazelle	East New Britain Province	Wet lowlands	Rural
Napapar No. 5	Gazelle	East New Britain Province	Wet lowlands	Rural

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

PNG) conducted the surveys. Efforts to involve provincial and district agricultural extension officers were unsuccessful.

The questionnaire

The questionnaire was designed in English and then translated into Pidgin (a common language spoken in PNG). It was critically evaluated by the team and pre-tested at the Zumin village, Markham Valley. Following the testing the questions were refined. Both English and Pidgin versions were made available to all the interviewers for cross checking if required.

Interviews

Semi-structured group (16 villages) and household interviews (64) were conducted over four weeks (Table 2). The group interviews comprised peanut growers and other interested farmers and lasted for about one to two and half hours, while household interviews and farm visits took about three hours.

Farmers and other stakeholders in the survey villages were notified through progressive farmers and provincial and local government officers one to two weeks in advance. The team leader, village elder/ group leader or elected representative introduced the team. The purpose and objectives of the survey were explained in simple terms to make everyone understand, allay fears, and create a harmonious environment for free and fair interactions during the group and individual interviews. Pidgin was used during the interviews as most farmers are well conversant in it. However, the local dialect was used wherever necessary. The interviewees were allowed to seek clarification where there were any doubts and additional information on agricultural technologies was sought. The results of the survey were coded into an Excel spreadsheet and analysis was conducted using the Statistical Package for Social Scientists (SPSS), version 11.5.

Results and discussion

Crop awareness

All the respondents were familiar with peanut and most of them had been growing the crop for several years. At the time of survey, peanut crop was found in 60% of fields at various stages (seedling to harvest).

Crop varieties

Peanut introductions date back to the early missionary and European contacts. Peanuts in the Eastern Highlands Province were introduced before the 1970s. Two groups in the Markham Valley (Zifasing and Mampim villages) received peanuts before the 1970s. In East New Britain Province, the Tolai people have been growing peanuts since the 1930s while the Baining community was introduced to peanuts in the 1990s. Seven varieties of peanuts were recorded in the survey (Table 3).

All the farmers interviewed seemed to be well convinced about the potential of the crop and ability of peanut to develop as an industry in the near future because the climate and soils are conducive, and local demand is not yet fully met. Furthermore, farmers appreciated peanut as a fast selling commodity with fair returns. Farmers are willing to accept new varieties with superior performance and adaptability.

Popularity of peanut compared with other crops

Group interviews and household surveys clearly brought out the popularity and importance of peanut. Although peanut is not considered as a food crop, when crops were ranked by food, income generation, land allocation and time allocation categories, peanut still ranked as one of the top five crops that generated income for the family. In the food category, sweet potato is the most significant crop across all

Table 2. Details of interviews conducted in various provinces of Papua New Guinea

Province/region	Total number of farmers interviewed	Number of households growing peanuts	Individual household grower interviews	Percentage growing peanut/site	Percentage of households growing peanuts
Eastern Highlands	150	71	14	47.3	17.3
Markham Valley/Morobe Province	91	57	16	62.6	13.9
National Capital District	27	24	17	88.9	5.8
East New Britain	143	85	17	59.4	20.7
Total	411	237	64		57.7

Table 3. Number of popular local peanut varieties in surveyed villages in Papua New Guinea

Province/region	Site/village	Number of varieties
Eastern Highlands	Samogoyufa	6
Eastern Highlands	Korofeigu	5
Eastern Highlands	Sikenafamo	5
Eastern Highlands	Ikana	6
Markham	Mampim	4
Markham	Sira Sira	3
Markham	Zifasing (40 mile)	4
Markham	Naraguam (Yalu)	4
National Capital District	9 mile/Makana	4
National Capital District	6 mile Dump	2
National Capital District	Erima/Wildlife	3
National Capital District	Gerehu	3
East New Britain	Rabagi No. 2	6
East New Britain	Malasaet	2
East New Britain	Navunaram	3
East New Britain	Napapar No. 5	7

agro-ecological regions. About 70% of the groups interviewed depended on sweet potato as their main food source, while 19% ranked cooking banana as their number one food. Taro and Singapore taro *(Xanthosoma sagittifolium)* were also ranked as first choice food crops.

More than 60% of the groups interviewed ranked cassava *(Manihot esculenta)* as the second most important food crop, while cooking banana (*Musa* spp.) was the third most important food crop across all regions. Figure 1 shows crops that were ranked number one by groups across all regions for providing food. Peanut was given the top rank by about 40% of the groups interviewed in the income category while about 20% ranked coffee as the number one income earner. Betel nut *(Areca catechu)*, beans, coconut, cucumber and sweet potato were also ranked first by one group for food and another for generating income. However, in the four highland locations, two ranked coffee, one ranked sweet potato and only one group ranked peanut as the primary income earner. By contrast, all four sites in the National Capital District ranked peanut as number one.

In the individual household interviews, peanut was listed among the top three crops as a source of income for the family. About 80% of the households were actually growing peanuts at the time of interview and rated peanut as number one among the three crops stated as earning income for the family. Figure 2 shows the crops that were ranked number one by all groups for earning income and Figure 3 shows crops similarly rated by individual households across all the regions.

Production practices

Cropping season

Most farmers grow two or three peanut crops a year, but not necessarily on the same piece of land. In the National Capital District, 88% of farmers grow peanuts only once while 12% cultivate two crops a year. In the Eastern Highlands Province, 42% of farmers grow peanuts only once, another 42% grow two crops in a year while 16% plant more than two crops in one year. In the Markham Valley, more than 70% of farmers grow three crops or more in a year, while 27% grow less than three crops per year. More than 50% of farmers in East New Britain Province

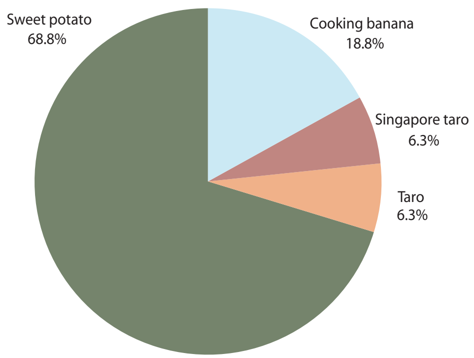

Figure 1. Top food crops in Papua New Guinea, as ranked by interview groups

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

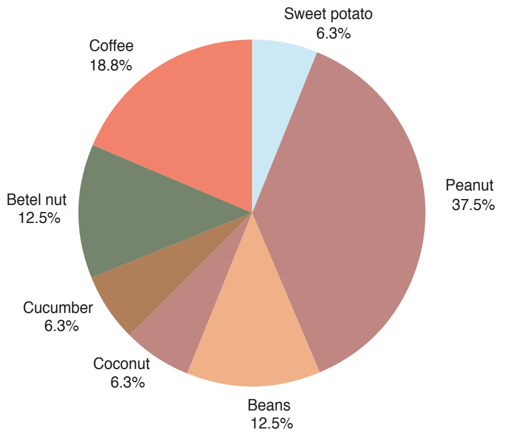

Figure 2. Crops ranked number one by Papua New Guinea groups for income earning

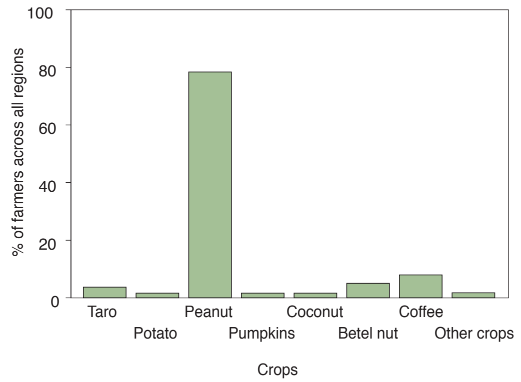

Figure 3. Crops rated number one by Papua New Guinea individuals for income

cultivate three crops a year and almost 30% have been growing four peanut crops in a year. However, 20% of farmers in East New Britain have cultivated only two peanut crops in a calendar year. Farmers have experienced yield decline and increased rat problems when peanuts are repeatedly grown on the same land, whereas rotation with crops such as sweet potato increases yields.

It is obvious that a favourable climate is important for good peanut production. Cropping seasons therefore coincide with the onset of the wet seasons (October and March). Most farmers in the highlands plant peanuts between November and February, whereas the majority of farmers in the Markham Valley do their planting between January and March. In the National Capital District, most farmers plant the crop between December and February. Farmers in East New Britain Province plant peanuts mostly in March and April. Nearly everyone indicated that peanuts planted outside the optimal time produced lower yields. However, some farmers in the Markham Valley cultivate peanut during the off-season to take advantage of better market demand and prices. Table 4 shows the most favoured planting months.

Table 4. Frequency distribution of time for planting peanut in various provinces in Papua New Guinea

Planting month	Peanut growing region								Total	
	Eastern Highlands Province		Markham Valley (Morobe Province)		National Capital District		East New Britain Province			
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
October	1	7			1	6			2	3
November	4	21	1	6	1	6			6	9
December	3	29			2	12			5	8
January	3	21	3	19	9	53			15	23
February	2	14	5	31	3	18	1	6	11	17
March	1	7	6	38	1	6	9	53	17	27
April							7	41	7	11
Any month			1	6					1	2
Total	14	100	16	100	17	100	17	100	64	100

Land allocation

Land allocation is based on the importance of the crop as the main food source or major income earner. In the Eastern Highlands Province, more land is allocated to coffee as the main cash crop and sweet potato as staple food. In the Markham Valley farmers allocate more land to peanuts, taro and betel nut due to the high proportion of income that accrues from these crops. Most peri-urban farmers in the National Capital District allocate larger portions of the cultivated land to peanuts while other crops, viz. maize (*Zea mays*), cucumber (*Cucumis sativus*), sweet potato and cassava, are planted either as intercrop or on the boundaries to generate additional income. Intercropping is a common practice in the Gazelle and Kokopo areas of East New Britain Province to maximise land use and food production. However, income-generating crops such as cocoa *(Theobroma cacao)*, coconut *(Cocos nucifera)* and peanut occupy more land. The average individual household farm size measured for 60 farms was 0.12 ha, with a range of 0.0072–1.86 ha. In general, plot sizes were largest in the Markham and smallest in the Eastern Highlands and East New Britain with some clustering around a median value of 0.13 ha in the Markham, 0.09 ha in the National Capital District and 0.03 ha in the other two provinces.

Site selection

Selection of site is important for good peanut yields. Some 70% of all gardens surveyed were on flat to gently sloping (<5°) land. However, in the National Capital District, nearly 60% of the farmers were cultivating the hillsides of Port Moresby because of limited choice. In the Markham Valley, farmers in the Sira Sira village plant peanuts on mountainsides and in gullies with 21–30° slope, because of the physical geography of the area. In Eastern Highlands Province, 25% of the farmers cultivate peanuts on hills of more than 20° slope. More than 50% of the farmers across all regions use the same piece of land for peanuts after a short grass fallow. All farmers in the National Capital District return to the same land every year because of non availability of additional land. In the Markham Valley, 50% of the farmers allow for a bush fallow or plant fallow before returning for the next peanut crop. Nearly all farmers in East New Britain Province and half of those in Eastern Highlands rotate peanuts with sweet potato, cassava or mixed crop with maize. Nearly 70% of farmers in all regions cultivate peanut in either loam or silty loam soils, 18% plant peanuts in clay loam and about 15% grow peanuts in sandy loam or sandy soils. Table 5 shows the field assessment of the type of soil on which peanuts were grown.

Tillage and fertility management

The majority of farmers till their land using basic tools such as spades, hoes, bush knives and sticks. Land preparation by tractor is practised only in the Markham Valley. Farmers take up to two days or more to complete tillage and land preparation depending on farm size and labour availability. In the National Capital District land is prepared at least twice before sowing peanut.

Crop rotation and incorporation of crop residues are the main soil fertility management practices. In Eastern Highlands Province and East New Britain Province, crop rotation is common while Markham farmers prefer to incorporate crop residues. Farmers in the National Capital District allow grass to grow in the fallow and leave crop residues in the garden to help restore soil fertility.

Seed source

About 60% of respondents across all regions obtained seeds from the market, while 30% saved seeds from the previous crop. The remaining farmers sourced

Table 5. Major soil types for peanut cultivation in Papua New Guinea

Soil type	Farms in each survey region (%)				Total (%)
	EHP	Markham Valley (MP)	ENBP	NCD	
Loam	57	19	18	18	27
Silty loam	7	44	59	35	38
Clay loam	29	13	23	18	20
Sandy loam	7	25		11	10
Sandy soil				18	5
Total	100	100	100	100	100

Note: EHP, Eastern Highlands Province; MP, Morobe Province; ENBP, East New Britain Province; NCD, National Capital District

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

seeds from friends or relatives free of charge. More farmers in the Markham Valley retain seeds for planting than those in other regions. More than 94% of farmers in the National Capital District save money from peanut sales to buy seeds for the following season.

Seed treatment

All farmers in East New Britain Province and National Capital District soak seeds in water using plastic or aluminum containers for 24 hours prior to planting. In the Markham Valley, more than 90% of farmers soak seeds in water and discard the floaters and dead seeds before planting the healthy pre-germinated seeds. About 30% of farmers in the Eastern Highlands Province soak seeds in water, while 55% plant seeds without any form of treatment. Chemical treatments are not used widely. The soaking of seeds in water was perceived as security against seed losses in the soil due to pest and disease infections and the farmer is assured of good germination and quick crop establishment.

Sowing

The availability of labour and the size of the garden determine the time spent in sowing, which ranges from an hour to three days or more. Only 15% of farmers across the regions indicated that planting was completed in less than a day. The seeds or pre-germinated seeds were planted on mounds, ridges, flat ground or pre-dug holes measuring 10 cm in diameter and 5–10 cm in depth. Such holes are filled in during flowering and peg initiation to increase yield. The planting depth in all regions was found to be from 5 to 10 cm. Spacing was irregular with low plant density in all regions. In the National Capital District, more than 77% of farmers had <100,000 plants per ha and 23% had 100,000–150,000 plants per ha. In the Eastern Highlands Province nearly half of the farmers plant <100,000 plants per ha. In East New Britain, 53% of farmers grow 100,000–150,000 plants per ha and 47% grow more than 210,000 plants per ha. The majority of farmers in the Markham Valley were planting between 160,000 and 200,000 plants per ha (Table 6).

Role of women in peanut production

The survey showed that women in all regions are heavily involved in peanut production. In the Eastern Highlands Province, activities such as tillage, planting, weeding, harvesting, cleaning, sorting and marketing are done by women while the men and boys assist in clearing bush and digging drains where necessary. In the Markham Valley and East New Britain Province, peanut cultivation is a communal effort involving all members of the family. Frequently other relatives, friends or organised groups assisted during peak periods such as planting, weeding and harvesting.

Of farmers in Eastern Highlands Province, National Capital District, and East New Britain Province, 60–65% indicated that women did the majority of garden maintenance, such as weeding. In the Markham Valley, less than 10% responded that weeding was done by women only, while 77% indicated that both men and women do the weeding. About 70% in all the regions said they weeded once or twice, while 30% weeded three or four times during the season. The main weeding is done during crop establishment 3–4 weeks after planting, at flowering and before maturity of the crop. Figure 4 indicates gender desegregation of activities in peanut production, marketing and utilisation in PNG.

Production costs

The major production costs are labour for planting, crop protection, harvest and post-harvest operations and seed. Many farmers in the Markham Valley hire tractors (K200 per day) for plant preparation, while hired labour is used for other operations. Seed cost

Table 6. Peanut planting density in different regions of Papua New Guinea

Planting density (per ha)	Growers in survey regions (%)				Total (%)
	Eastern Highlands Province	Markham Valley	East New Britain	National Capital District	
<100 000	50	13	77		34
100 000–150 000	17	33	23	53	33
160 000–200 000	17	47			15
210 000 +	17	7		47	18
Total	100	100	100	100	100

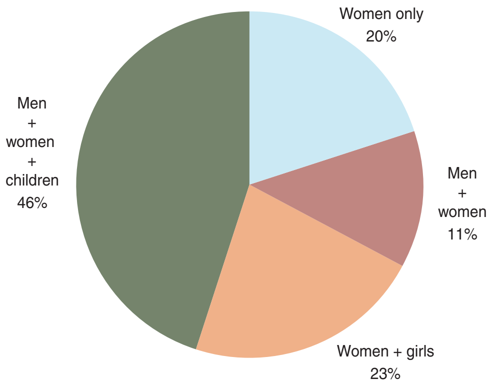

Figure 4. Weeding as a gender desegregated activity in Papua New Guinea

ranged between K180 (100,000 plants per ha) to K450 (250,000 plants per ha). Details about average cost of cultivation are presented in Table 7. The gross margin will be between K959–2097 per ha, depending on cultural methods and prevailing market prices for peanuts.

Post-harvest, utilisation and marketing

The majority of farmers harvest peanuts in 3–4 months from planting. A single harvest is a common practice, but some prefer multiple harvests over a period of 1–2 weeks to sell fresh produce instead of dried peanuts. Harvesting is done manually by uprooting the crop or digging with spades. It takes up to two days or more to complete harvesting depending on farm size, availability of labour and sales.

Sorting and cleaning

The indigenous Markham farmers leave uprooted peanuts with stalk in the gardens to allow for drying before the pods are plucked and bagged in stock feed bags. Farmers in the valley from other regions trim the roots and lateral stalks, and unplucked pods on the stalk are either sold straightaway or left overnight in the house to be sold next day. More than 60% of the farmers in the four regions never pluck the pods while the remainder, mainly the indigenous Markham farmers, pluck the pods and sell peanuts in stock feed bags. About 46% of all the farmers interviewed washed the pods. Over 66% of farmers dried peanuts in the sun for 2–3 days or up to 1 week before selling, while 34% of respondents sold fresh peanuts.

Storage

The majority of farmers from Eastern Highlands Province, Markham Valley and East New Britain Province store 10–20% of the best pods from the harvest as seed for the next planting. The storage of seeds might take up to 2 months or more. Peri-urban farmers in the National Capital District experience poor seed viability and germination when seeds are stored for a longer period because of high temperature and poor storage conditions. As the planting in the National Capital District usually occurs only once a year, farmers prefer to buy the seed from market. More than 90% of farmers in the four regions consumed less than 10% of the produce from the harvest. A similar proportion is given to friends or relatives who have assisted in planting, weeding and harvesting. Unsold peanuts were usually stored in the house to prevent theft.

Marketing

Peanut farmers sell their produce in the urban, local and roadside markets, in various forms, such as fresh on bunch, fresh and loose, boiled on bunch, boiled and loose, roasted on bunch, roasted and loose, dried and loose, dried in bags, or fried and salted, to suit consumer preference. However, first preference for more than 90% of farmers across all regions is to sell peanuts fresh on the bunch. The second preference is

Table 7. Cost of peanut cultivation per hectare in Papua New Guinea

Item	Qty	Units	Unit cost (K)	Person days	Cost/ha (K)
Tractor	2	1	150	1	300
Seed (100,000 plants/ha)	3	bags	60		180
Labour (planting)	1	5 people	8	1	40
Labour (weeding)	3	10 people	8	2	480
Labour (harvesting)	1	6 people	8	1	48
Stock feed bag	60	bags	1.50		90
Total					1138

fresh and loose. This implies that peanuts are sold soon after harvest. In Eastern Highlands Province and East New Britain Province, all farmers prefer selling fresh on the bunch. In the National Capital District more than 90% of farmers sell fresh on the bunch immediately after harvest. In the Markham Valley, about 70% of the farmers sell fresh on the bunch, while the rest sell peanut in shell and in bags. In East New Britain Province, 56% of farmers can sell all peanuts in a day while those in other regions take about two days. Generally, 80% of respondents said that they can sell their produce within a week.

Women and girls do most of the selling. In the Eastern Highlands Province and National Capital District, 100% of the respondents indicated that only women did the marketing and controlled the money. In East New Britain Province, 75% of the respondents indicated that women and girls were involved in marketing. Nonetheless, in the Markham Valley 75% of farmers responded that men, women and children were involved in marketing and sharing of income based on consensus.

Wholesale price

The wholesale prices of peanuts in bags sold in the Markham Valley and Goroka urban markets — the latter sourced from the remote Karimui District in Simbu Province — change with demand and supply. During the seasonal peak period when the market becomes flooded with peanuts, farmers sell them for K25–40 per bag. During the off-season, on the other hand, when supply is low and demand high, they charge K70–100 per bag. The average price over the year is about K60 per bag. The medium sized bags hold an average of 25.8 kg dried peanut in shell.

Retail price

The retail prices from the Fresh Produce Development Agency in the major urban markets of Goroka, Mt Hagen, Lae, Kokopo and Gordons (Port Moresby) range from K1.70–14 per kg dried nuts in shell. Peanuts sold in Port Moresby are extremely expensive compared to other provincial markets, with prices ranging from K4.65–14 per kg. The prices in Mt Hagen market have been over K4 per kg in almost every month except January and March. The prices in Goroka, Lae and Kokopo markets have been below K4 per kg except during November and December. Generally, during the peak supply period of February to April, prices are lower in all urban markets (Figure 5). The prices of a heavy bearing bunch range from K0.20 in Eastern Highlands Province to K1.0 in the National Capital District.

Production constraints

One of the major production constraints expressed by a high proportion of the farmers was insect pest problems, particularly grubs and pod borers. About 11% of the respondents across all regions believed that choice of variety was a major problem, while about 40% of all farmers in the National Capital District thought that the variety per se was a significant problem. Conversely, 30% of all farmers felt

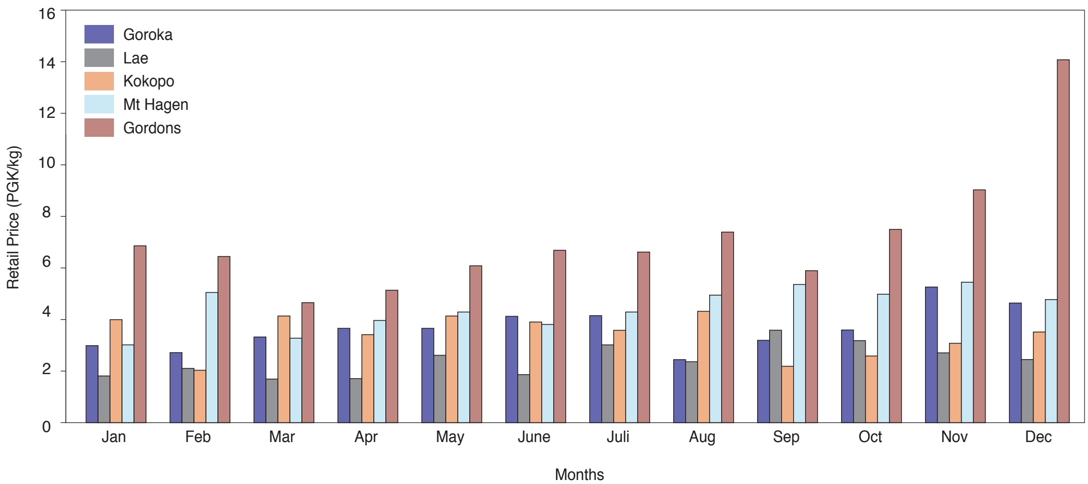

Figure 5. Seasonal changes in the retail price of peanuts in major urban markets in Papua New Guinea (Source: Fresh Produce Development Agency)

that variety choice was a minor problem. Soil fertility was stated as being a major problem in Eastern Highlands Province and East New Britain Province. Land shortage and management are major constraints in the National Capital District and East New Britain Province (particularly in the densely populated areas of Gazelle and Kokopo Districts). Parrots and rats cause significant yield losses in the Markham Valley and East New Britain Province. Although land shortage and inadequate management skills were expressed as constraints by most regions, respondents in the Markham Valley felt that they possessed adequate land, and crop husbandry and management were not major constraints.

Foliar diseases are a significant problem in the National Capital District. The majority of respondents observed late leaf spot *(Phaeoisariopsis personata)* and peanut rust *(Puccinia arachidis)* at maturity. Yield losses due to white grubs and rats were clear to the farmers but they were unaware of yield losses caused by diseases.

All farmers interviewed were quite knowledgeable about planting season and weather patterns that influence peanut crop production. The majority of farmers were aware that unfavourable weather such as long dry spells, drought, prolonged wet seasons, and flooding contributed to poor crops and low yield. The farmers also stated poor soils as one of the contributing factors to poor peanut growth and yield. Only a minority of respondents identified poor crop husbandry and management as production constraints.

Agricultural extension and training in peanut production and utilisation were stated to be nil in all regions except Eastern Highlands Province, where 25% of the respondents had government extension officers visiting them occasionally. However, these responses came from the group interviews, which included many farmers not growing peanuts. Extension officers may not possess the necessary resources, skills or updated technologies on peanut production. It is also possible that extension officers think peanut is an insignificant crop given its low commercial status.

Transporting of peanuts to the markets was seen as a minor problem in the locations surveyed. However, this may not be the true picture for rural PNG because poor infrastructure and road maintenance are nationwide problems. The rising cost of air freight is discouraging peanut farmers in remote places such as Marawaka and Obura in the Eastern Highlands and Karimui in Simbu Province (known for producing good quality peanuts) from increasing production or marketing their produce. Marketing was not an issue in the National Capital District and only a minor problem in the Markham Valley. In the other two regions, 50% of farmers expressed the view that good market outlets were inaccessible to them.

Conclusions

Sixty per cent of the farming households in the survey areas grow peanuts, covering an estimated land area of 14,000 ha. The production estimate of 12,600 t of peanut pods earned a gross income of K29,359,000. An estimated gross margin of K960 per ha is equivalent to A$393 per ha.

Peanut is an established crop in the farming systems and one of the most useful crops in rotation to maintain soil fertility. It is a prominent cash crop in the surveyed areas, being ranked among the top five crops across all regions for generating income.

Peanut plays a significant role in increasing individual household incomes, thus contributing to improvement in living standards. Peri-urban farmers in the outskirts of Lae City (Morobe Province) and Port Moresby City (National Capital District) respect this humble crop, as it contributes greatly to school fees, land rents, electricity and water bills and other social obligations. A farmer travelling between Goroka and Port Moresby every year at a return air fare of about K800 just to grow and sell peanuts in the National Capital District is a testimony to what peanut can do to an average income earner in PNG where choice of alternative cash crops is limiting.

The women folk in particular, vigorously pursue peanut cultivation for income generation. This was especially true for women in the highlands where they take advantage of this crop and control the income from peanuts, while their spouses concentrate on income from coffee. There is no doubt that women will play a major role in technology transfer and expansion of peanut production, quality improvement, utilisation and marketing in PNG.

Farmers, particularly women, could increase yield and benefit more from peanut if the following were considered in current or future collaborative peanut research and development:

- Evaluation, identification and distribution of new improved varieties with promising attributes of adaptation, yield, pest and disease tolerance, drought tolerance, ease of harvest by hand and better taste (increased fat content);
- Identify and recommend optimum plant densities to maximise production;
- Soil fertility and plant nutrition;
- Pest and disease management strategies;
- Studies on role of women in peanut production to influence change in the community;

- Information dissemination and extension on improved production and post harvest technologies;
- Investigation of various planting techniques practised by farmers;
- Seed handling technologies including seed storage, seed treatments etc. to improve seed quality, viability and supply;
- Awareness on aflatoxin contamination;
- Strategies to minimise aflatoxin to acceptable levels.
- Better marketing strategies and improvement in transport infrastructure will boost peanut production; help maintain quality and increase utilisation and incomes for many peanut producers in the rural areas of Papua New Guinea.

Acknowledgments

The authors wish to thank Dr Geoff Wiles (former Chief Scientist, NARI) for his support in developing the survey questionnaires and Dr Alan Quartermain (Chief Scientist, NARI) for valuable editorial comments on the manuscript. The authors are grateful to the Research Program Leaders and Resources Managers of NARI Research Stations at Aiyura, Bubia, Kerevat and Laloki for their logistical support. Many thanks are due to a number of technical and field staff of NARI and HOPE (NGO) volunteers for their time and participation in the surveys. The peanut market price data were obtained from Fresh Produce Development Agency (FPDA) publications. We would like to sincerely acknowledge the active co-operation and contribution of farmers and their families in the four surveyed regions of Eastern Highlands Province, Markham, East New Britain Province and the National Capital District.

References

Allen B.J., Bourke R.M. and Hide R.L. 1995 The sustainability of Papua New Guinea agricultural systems: the conceptual background. Global Environment Change 5, 297–312.

Keig G. 1999. Rural population growth in Papua New Guinea 1980–1990. ACIAR project ASEM 1996/044 report 26 p.

McAlpine J.R., Freyne D.F. and Keig G. 2001. Land use and rural population change in rural PNG 1975–1995. In 'Food security in Papua New Guinea', eds Bourke R.M., Allen, M.G. and Salisbury J. ACIAR Proceedings 99.

Wemin J.M. and Geob T. 2004. Peanut production, utilisation and marketing in Papua New Guinea: a peanut farmer survey. Project report for ACIAR Project ASEM 2001/055. National Agricultural Research Institute, Aiyura, Papua New Guinea.

NARI staff conducting a peanut farmer survey at Bena Bena in the Eastern Highlands Province, Papua New Guinea

Status of aflatoxin contamination in Papua New Guinea peanuts

Rao C.N. Rachaputi[1], Peter Corbett[2], A. Ramakrishna[3], G.C. Wright[1], J. Wemin[3], T. Geob[3], Y. Tomda[3] and Trevor Wilson[1]

[1]*Department of Primary Industries and Fisheries, PO Box 23, Kingaroy, Queensland 4610, Australia; email: rao.rachaputi.dpi.qld.gov.au*

[2]*National Agricultural Research Institute, Chemistry Laboratory, PO Box 8277, Boroko, National Capital District, Papua New Guinea*

[3]*National Agricultural Research Institute, PO Box 210, Aiyura, Eastern Highlands Province, Papua New Guinea*

Abstract

Aflatoxins are well recognised as a group of carcinogenic compounds, which are produced in peanut kernels by the fungi *Aspergillus flavus* and *A. parasiticus* under specific moisture and temperature conditions. In Papua New Guinea (PNG) nearly all peanuts produced are consumed domestically as food, representing an important part of the diet. Peanuts are sold at roadside markets in various forms such as fresh on bunch, dried, boiled, roasted pods, deep fried kernels and peanut butter.

As a part of the ASEM 2001/055 project, a survey was undertaken during 2003–05 to assess the level of aflatoxin contamination in peanuts sold at popular roadside markets in Eastern Highlands, East New Britain and Morobe provinces and the National Capital District. A total of 274 samples were collected from the popular markets and analysed for aflatoxin using mini-column assay.

There was considerable aflatoxin contamination in all the four markets with 22% positive samples in Morobe Province, 35% in East New Britain Province, 16% in the National Capital District and 12% in the Eastern Highlands Province. About 74% of samples contained aflatoxin levels <10 ppb and 6.5% of samples contained aflatoxin levels between 10 and 20 ppb. Although >80% of samples recorded less than 20 ppb, 5% of the samples contained unacceptable levels of aflatoxin (up to 1000 ppb). The higher levels of contamination were often present in the roasted and dry pod samples.

The results obtained from the aflatoxin survey and the APSIM modelling work that was done in the project enabled us to draw some conclusions and make recommendations for future work related to aflatoxin minimisation in PNG.

Introduction

Aflatoxins are a group of toxins produced in peanut kernels by the fungi *Aspergillus flavus* and *A. parasiticus* under specific moisture and temperature conditions. Aflatoxins are well recognised as a group of carcinogenic compounds. Chronic exposure to aflatoxins compromises immunity by interfering with protein metabolism and availability of multiple micronutrients that are critical to human health (Williams et al. 2004).

The *Aspergillus* fungi are ubiquitous and can infect many of the dietary staples such as rice, maize, cassava, nuts, chillies and spices, as well as peanuts. In peanut, aflatoxin production occurs in the fungus-infected kernels, depending on the environmental conditions during production, harvest, storage and food processing. The contamination of stored, inadequately dried produce is possible depending on storage conditions. Aflatoxin contamination in peanut is a worldwide phenomenon, but particularly severe in developing countries in Asia including the South Pacific region and Africa where there is little consumer awareness about the food safety issues related to aflatoxins. In these countries, food safety and security systems are not well developed to protect

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

consumers against these unsafe food products. While the international standard for bulk consignments of peanuts traded in the export market calls for a maximum level of 15 μg/kg (ppb) of total aflatoxins (Codex Standard 209-rev 1, 2001; <www.codexalimentarius.net>), maximum levels of aflatoxins allowed in human food range from 0–30 ppb, depending on the country involved (FDA 1995; Henry et al. 1999). In developed countries, consumers are more aware of food safety issues related to aflatoxin and are increasingly demanding those foods at risk meet strict regulatory standards. As a result, aflatoxin contamination in peanuts is closely monitored or regulated (van Egmond 1995).

In Papua New Guinea (PNG) more than 12,500 tonnes of peanuts are produced annually in small blocks of land or in backyard gardens with the major production occurring in Morobe, Eastern Highlands (EHP) and East New Britain (ENBP) provinces and the National Capital District (NCD). Most of the peanuts are sold in town roadside markets in various forms such as fresh on bunch, dried, boiled, roasted pods and deep fried kernels. There is some household production of peanut butter which is also sold in roadside markets. Nearly all peanuts produced in PNG are consumed domestically and they represent a significant component of both the rural and urban PNG diet, by providing a rich source of protein, oil and vitamins, especially to children and the poorer sections of the community. Peanut products (such as blanched, roasted nuts, peanut butter and oil) are also imported for sale in supermarkets for consumption by the urban population, suggesting there is good scope for expansion of domestic production and processing to displace imports, provided the products meet food safety standards.

A peanut farmer survey (Wemin and Geob 2004) noted that there was little awareness of the aflatoxin problem among farming communities, despite the crop being cultivated and consumed for the past few decades. Quantifying the extent of aflatoxin contamination at critical points in the production and supply chain is necessary to understand the magnitude of the problem and develop appropriate strategies to minimise its incidence and impact in the food chain. This aspect has been addressed separately by an AusAID-funded aflatoxin awareness project implemented by the National Agricultural Research Institute (NARI).

Early studies on aflatoxin contamination in PNG

There have been some limited 'snapshot' surveys in PNG to assess aflatoxin levels in peanut products which can be summarised as follows (Peter Corbett, pers. comm.):

1972 – Wookey	18 highlands samples tested, with half of them contaminated
1975 – Collin & Beam	No contamination from Koki market samples in NCD
1982 – Beard	No contamination from roasted peanut samples
1991 – Kaluwin	Four of eight peanut butter samples from the Markham Valley contaminated, values ranging from 31–135 ppb
1996 – NARI Chemistry	32 market samples collected from Western Highlands, Sepik laboratory, Morobe and ENB provinces and NCD. About 35% of samples contained aflatoxin levels between 5 and 20 ppb.
2002 – NARI Chemistry Laboratory	40 market samples collected from, Western Highlands, Sepik, Morobe, and ENB provinces and NCD. About 35% of samples contained aflatoxin levels between 5 and 20 ppb.

The results from the above surveys were variable, ranging from nil to high levels of aflatoxin in some samples and the reports often lacked information on the history of samples and possible reasons for contamination.

A survey was undertaken during 2003–05 to assess the level of aflatoxin contamination in peanuts sold at town markets and popular roadside markets in EHP, ENBP, Morobe Province and NCD. The major aim of the survey was to assess the aflatoxin contamination in various peanut products sold at the major roadside markets and to examine spatial and temporal trends in levels of aflatoxin contamination.

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

Material and methods

During 2003, a total of 86 peanut samples (including processed product) were collected from major market outlets in ENBP, EHP, Morobe and NCD (Table 1). In 2004, sampling was done more systematically with a total of 151 samples collected at bimonthly intervals to examine seasonal trends of aflatoxin in peanuts traded at the various markets. In 2005, sequential sampling continued with sampling occurring in February, May and July at the selected markets. Unfortunately, the data from the 2005 sampling were limited to only 37 samples collected in February, since the May and July samples were lost in a fire accident at the NARI chemistry laboratory in Port Moresby. Aflatoxin analyses were conducted using the mini-column assay (Holaday and Passwater 1969) which was installed as a part of the ASEM 2001/55 project.

Table 1. Total number of samples collected in the aflatoxin survey during 2003–05 in Papua New Guinea.

Market province	2003	2004	2005	Total
Eastern Highlands	26	37	11	74
East New Britain	25	30	0	55
Morobe	14	68	20	102
National Capital District	21	16	6	43
Total	86	151	37	274

Sample collection

Interviews and a questionnaire method were followed to collect as much information about the sample as possible during the sampling time (see Appendix 1). About 2 kg of pods were collected while sampling dry and fresh nut-in-shell peanut. Other forms of peanut products (i.e. roasted, boiled and fried etc.) were collected in small quantities (<250 g) where available. Pods were dried as soon after collection as possible at 80°C for 12 h in an oven to safe (<10%) moisture to prevent any aflatoxin production in storage. The pods were shelled and kernel samples (about 1 kg) were sent by air to the NARI chemistry laboratory in Port Moresby for aflatoxin analysis.

Aflatoxin assay

A mini-column assay (Holaday and Passwater 1969) was used to assess aflatoxin levels in the samples. After recording the weight of the kernel sample, aflatoxin in kernels was extracted by blending the sample in 80% methanol at a ratio of 1:2 (sample size to methanol volume). After further re-extraction to clean impurities, the final extract was passed through the mini-column which retained the aflatoxins. The concentration of the toxins in each test sample was assessed by visually comparing the intensity of luminescence in the mini-column under a UV lamp with a set of other columns containing standards with known aflatoxin concentration (i.e. 0, 20, 40, 80 and 100 ppb). The aflatoxin level of the sample was estimated by averaging the upper and lower limits of the standards between which the luminescence of the sample fell. Where the sample luminescence was similar to either of the standard limits, the aflatoxin level was recorded as being equal to the standard. The mini-column assay is a semi-quantitative measure as it only allows measurement of range in aflatoxin levels in a given sample, rather than an absolute amount.

Statistical analysis

The analysis of aflatoxin was conducted using the Statistical Package for Social Scientists (SPSS, version 11.5).

Results

This paper reports on the results obtained from aflatoxin analyses of 274 samples collected from July 2003 to February 2005 (Table 1).

Table 2. Aflatoxin contamination in peanut samples collected from various provinces of Papua New Guinea during 2003–05

Province	2003			2004			2005		
	Total samples	No. of +ve samples >10 ppb	Max aflatoxin (ppb)	Total samples	No. of +ve samples >10 ppb	Max aflatoxin (ppb)	Total samples	No. of +ve samples >10 ppb	Max aflatoxin (ppb)
Eastern Highlands	26	3	20	37	4	50	11	2	500
East New Britain	25	6	20	30	12	400	0	0	NA
Morobe	14	1	20	68	22	900	20	0	0
National Capital District	21	0	10	16	4	1000	6	3	500
	112	10 (9%)		151	42 (27%)		37	5 (13%)	

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

Table 3. Distribution of aflatoxin contamination in Papua New Guinea in various years

Aflotoxin level (ppb)	2003 No. of samples	2003 %	2004 No. of samples	2004 %	2005 No. of samples	2005 %	Total No. of samples	Total %
<10	67	77.9	103	68.2	32	86.5	202	73.7
11–100	11	12.8	26	17.2	0	0.0	37	13.5
101–500	8	9.3	15	9.9	5	13.5	28	10.2
>500	0	0.0	7	4.6	0	0.0	7	2.6
Total	86	100	151	100	37	100	274	100
Range	10 – 400		10 – 1000		10 – 500		<10 – >1000	
Mean	36		93		76		73	
Mean rank	129		145		124			

Kruskall Wallis statistic = 6.0; $p = 0.05$.

The data on aflatoxin contamination recorded during the 2003–05 period from each of the provinces are summarised in Table 2.

The data pooled over 3 years showed that the proportions of aflatoxin positive samples (>10 ppb) were of the order of 12% in EHP, 22% in Morobe, 35% in ENBP and 16% in NCD, although the results from ENBP and NCD were based on limited numbers of samples. When the data from provinces were pooled, there were 9%, 27% and 13% positive samples (>10 ppb) during 2003, 2004 and 2005, respectively; resulting in an overall contamination of 16%, over a total of 274 samples (Table 2).

It should be noted that the number of samples collected varied between the provinces. The frequency of positive contamination was, in general, higher in 2004 than in 2003 or 2005. However, the data for the 2005 year were from the February sampling only.

The data pooled over the markets and years indicate that 74% of the samples recorded <10 ppb (Table 3). At the extremes, only 68% of samples in 2004 were at <10 ppb level compared with 86% in 2005. There were much higher levels of aflatoxin in all years, with both 2004 and 2005 having around 14% of samples above 100 ppb. However, sporadic and multiple occurrences of unacceptable levels of aflatoxin (up to 1000 ppb) in the 2004 and 2005 year samples were a matter of some concern. These levels were far above the food safety limits allowed for human consumption.

Because of the asymmetrical spread of the data in each year, it would not be valid to compare the means using a t-test. The data were ranked and the mean ranks compared using a Kruskall-Wallis test. This showed that the observed aflatoxin levels in the year 2004 generally ranked higher than those in the years 2003 and 2005. The difference between the mean ranks in 2003 and 2004 is significant at a probability of 0.05%.

Spatial and temporal distribution of aflatoxin contamination in various markets

The regional difference in aflatoxin contamination is summarised in Table 4. The proportion of samples which recorded <10 ppb were in the order of 87%, 70%, 70%, 67% in EHP, Morobe, NCD and ENBP,

Table 4. Distribution of aflatoxin contamination in various provinces of Papua New Guinea

Aflatoxin (ppb)	EHP No.	EHP %	Morobe No.	Morobe %	NCD No.	NCD %	ENBP No.	ENBP %	Total No.	Total &
<10	64	86.5	71	69.6	30	69.8	37	67.3	202	73.7
11-100	8	10.8	16	15.7	1	2.3	12	21.8	37	13.5
101-500	2	2.7	12	11.8	8	18.6	6	10.9	28	10.2
>500	0	0.0	3	2.9	4	9.3	0	0.0	7	2.6
Total	74	100%	102	100%	43	100	55	100%	274	100%
Mean	26.2		81.0		158.1		52.9		72.6	
Mean rank	118		143		148		143			

Kruskall Wallis statistic = 10.0; $p = 0.019$.
Note: EHP, Eastern Highlands Province; NCD, National Capital District; ENBP, East New Britain Province.

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

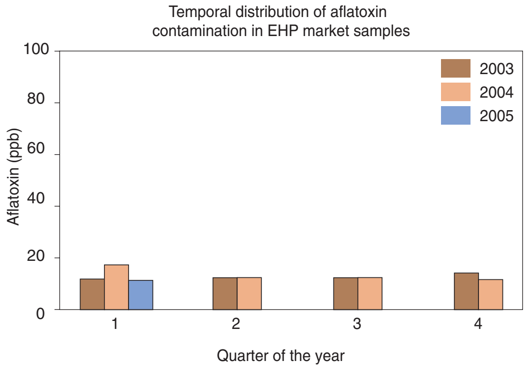

Figure 1. Temporal distribution of aflatoxin contamination in market samples from Eastern Highlands Province, Papua New Guinea

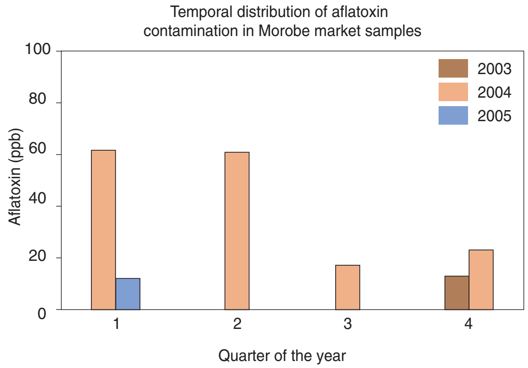

Figure 2. Temporal distribution of aflatoxin contamination in market samples from Morobe Province, Papua New Guinea

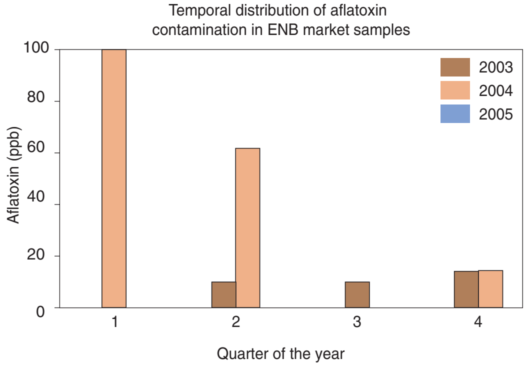

Figure 3. Temporal distribution of aflatoxin contamination in market samples from East New Britain Province, Papua New Guinea

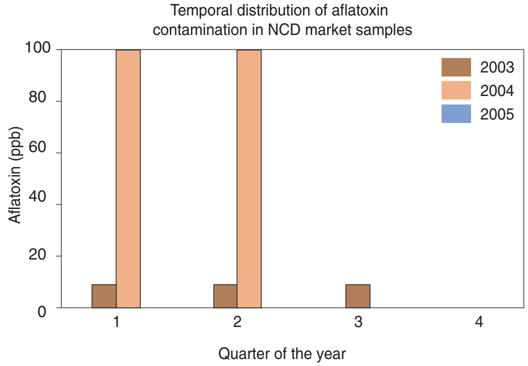

Figure 4. Temporal distribution of aflatoxin contamination in market samples from the National Capital District, Papua New Guinea

respectively. Levels of >500 ppb were recorded only in Morobe Province (3%) and NCD (9%).

The data were grouped based on the time of sampling to examine if there were any temporal trends in the severity of aflatoxin contamination in the various provinces. The data were pooled into four quarters per year and the aflatoxin data averaged over the number of samples collected during each of the four quarters. The results for EHP, Morobe, ENBP and NCD markets presented in Figures 1 to 4, respectively, show that aflatoxin contamination was minimal (<10 ppb) in EHP, except in the first quarter of 2004. In Morobe, ENBP and the NCD, high levels of aflatoxin were observed during the first and second quarters of the year 2004 (Figs 2, 3 and 4), compared to the third and fourth quarters. It should be noted that the number of samples collected during 2004 was much higher (151) than in 2003 (86) and 2005 (37) and hence provided a more rigorous sampling regime.

Further analysis was conducted to examine the distribution of aflatoxin across various peanut products sold in the market i.e. fresh, dry or boiled pods and deep fried or roasted kernels. Not all peanut products were available at each sampling time, resulting in some gaps in the data. In samples where the information on product form was not available, the data were categorised as ‘unknown’. The distribution of aflatoxin in various peanut products sold at roadside markets is presented for each region in Tables 5–8.

At markets in EHP, low levels of aflatoxins (up to 17 ppb) were detected in dry pod samples during 2003 and 2004. However, in 2005 very high levels

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

Table 5. Distribution of aflatoxin contamination in various forms of peanut sold in markets of Eastern Highlands Province, Papua New Guinea

Product form	2003		2004		2005	
	No. of samples	Mean aflatoxin (ppb)	No. of samples	Mean aflatoxin (ppb)	No. of samples	Mean aflatoxin (ppb)
Boiled pods	N/A	N/A	2	<10	3	<10
Fresh pods	17	<10	18	11	3	<10
Dry pods	9	14	14	17	4	<10
Roasted	N/A	N/A	3	12	2	500

N/A – data not available.

Table 6. Distribution of aflatoxin contamination in various peanut products sold in markets in Morobe, Papua New Guinea

Product form	2003		2004		2005	
	No. of samples	Mean aflatoxin (ppb)	No. of samples	Mean aflatoxin (ppb)	No. of samples	Mean aflatoxin (ppb)
Deep fried kernels	N/A	N/A	N/A	N/A	2	<10
Fresh pods	N/A	N/A	26	20	6	<10
Dry pods	11	11	20	81	3	<10
Roasted kernel	N/A	N/A	2	850	3	22
Unknown			3	10	17	20

N/A – data not available.

Table 7. Distribution of aflatoxin contamination in various forms of peanut sold in markets of East New Britain, Papua New Guinea

Product form	2003		2004	
	No. of samples	Mean aflatoxin (ppb)	No. of samples	Mean aflatoxin (ppb)
Fresh pods	N/A	N/A	24	77
Dry pods	17	14	4	40
Unknown	8	<10	2	300

N/A – data not available.

Table 8. Distribution of aflatoxin contamination in various forms of peanut sold in markets of the National Capital District, Papua New Guinea

Product form	2003		2004		2005	
	No. of samples	Mean aflatoxin (ppb)	No. of samples	Mean aflatoxin (ppb)	No. of samples	Mean aflatoxin (ppb)
Fresh pods	15	<10	4	<10	N/A	N./A
Dry pods	6	<10	6	762	3	500
Roasted kernel	N/A	N/A	N/A	N/A	3	<10
Unknown			6	<10		

N/A – data not available.

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

(up to 500 ppb) were detected in roasted kernel samples (Table 5).

Only limited data were available for Morobe Province in 2003. However, the results from 2004 showed that almost all types of peanut products were contaminated, with very high levels (>850 ppb) occurring in some roasted samples. In 2005, data from the February sampling indicated that roasted kernel samples again tested positive for aflatoxin, with samples from the 'unknown' group also being contaminated (Table 6)

In markets of ENBP, samples did not represent all types of peanut product and sampling was limited to 2003 and 2004. This limited data showed high levels of aflatoxin (ranging from 40 to >300 ppb) in fresh, dry as well as unknown categories from the 2004 samples (Table 7).

Aflatoxin analysis of 43 samples drawn from markets in the NCD showed that dry pod samples contained high levels of aflatoxin in both 2004 (>760 ppb) and 2005 (>500 ppb) (Table 8).

Discussion

The farmer survey conducted in the four major peanut growing regions of PNG showed that peanut ranked amongst the top five income generating crops grown by smallholders in the surveyed regions and represents one of the most commonly traded commodities in popular roadside markets (Wemin and Geob 2004). Peanuts also form an important part of the diet in PNG communities, by providing high quality protein, oil, vitamins and nutrients that offer significant health benefits. However, significant volumes of peanut products (such as blanched, roasted nuts, peanut butter and oil) are also imported for sale in supermarkets for consumption by the urban population. While peanuts are considered a profitable cash crop and nutritious food, consumption of poor (deteriorated) quality kernels can pose some serious health hazards. Although poor quality kernels (which are major sources of aflatoxin) may represent a minor proportion of a total sample, their presence can affect the overall quality of the produce.

Aflatoxins, which are produced by the *Aspergillus flavus* and *A. parasiticus* fungi, are the major factors causing quality deterioration in peanuts. A significant amount of information on aflatoxin incidence and its management in peanut has been generated over the last three decades (Harkness et al. 1966; Dickens and Khalsa 1967; Cole et al. 1989, 1995; NageswaraRao Rachaputi et al. 2002). These researchers have shown that while it is not possible to eliminate aflatoxin from peanuts with present day technologies, it is possible to minimise the contamination in edible peanut by using simple pre- and post-harvest management practices.

The survey was aimed at assessing the extent of aflatoxin contamination in peanuts traded in the local markets for consumption by a majority of regional communities. Hence, major roadside and semi-urban markets were targeted for sampling in the belief that domestic peanuts traded at these sites markets best represent the quality of peanuts available for local consumption. The paper examines the regional differences, time trends and distribution of aflatoxin contamination in a variety of peanut products.

To our knowledge, this study represents the first of its kind in assessing the status of aflatoxin contamination in domestic peanuts sold for human consumption in four major peanut producing regions of PNG. The survey is by no means complete as information is missing (due to sampling errors, unavailability of data, loss of samples etc.) and it does not include sampling of peanuts in the field or imported peanut products sold in urban supermarkets.

The results of the survey showed that 16% of the 274 samples collected during the 2003–05 period tested positive for aflatoxin (>10 ppb). There was considerable variation in incidence of aflatoxin in peanuts between various markets, with the contamination occurring at 22% in Morobe, 35% in ENBP, 16% in NCD and 12% in EHP markets. Lower aflatoxin levels in EHP could be due to higher rainfall and cooler temperatures during the cropping period, a hypothesis supported by the low pre-harvest aflatoxin risk predicted by the APSIM-peanut model (see Chauhan et al. 2006 in these proceedings). However, this situation does not preclude possible post-harvest contamination during storage and/or processing. Indeed, the data showed the occurrence of high levels of aflatoxin in processed (roasted) samples drawn from EHP markets during 2005, implicating possible post-harvest and processing issues (Table 3).

Interestingly, the data indicated some temporal trends with aflatoxin contamination being generally higher in the first and second quarters in Morobe, ENBP and the NCD (Figs 1 to 4). It was not possible to pinpoint the exact stage at which contamination might have occurred, although it is well known that fungal invasion and contamination often begin before harvest in the field and can be promoted depending on the growing conditions (severity of drought and soil temperature), harvesting, storage and processing methods. In PNG, peanuts are sun-dried in farmers' fields and packed in 50 kg flour-type plastic bags. Peanuts are stored at various stages after harvest for varying periods — they may remain in the field, or with the farmer until taken to market or be stored in transit at the marketplace until sold. The farmer

Jimmy Resimesi of NARI sampling peanuts from a market at Lae, Papua New Guinea for aflatoxin analysis.

Timothy Geob (front) and Yanding Tomda (back) of NARI undergoing training in aflatoxin analysis, at DPI&F, Kingaroy, Queensland, Australia.

survey also noted that movement of peanuts from the Markham Valley to other provinces either by road, ship and air are not uncommon during peak demand periods. The condition of storage and weather during transport can influence peanut quality. Peanuts dried to a satisfactory level (<10% moisture) before storage can develop local wet pockets which can favour aflatoxin production as a result of poor storage (high humidity, temperatures and incidence of storage pests).

The survey also noted that a practice of re-wetting of pods to freshen them for sale is common in local markets. Although the survey contained no direct evidence of an impact of re-wetting kernels on aflatoxin production, it is well known that an increase in kernel water activity levels can directly lead to fungal growth and aflatoxin production in a short time span. It was apparent that roasted and dry pod samples often contained higher levels of contamination (Tables 5–8).

While it is not possible to control climatic conditions during the growing period, considerable success in minimising aflatoxin contamination can be achieved by pre-cleaning (separating extraneous and poor quality damaged, shrivelled, mouldy pods) before storing and a secondary cleaning (separating discoloured, shrivelled, mouldy and damaged kernels) before processing. Studies have shown that a major portion (80%) of the toxin is associated with damaged and shrivelled kernels (NageswaraRao Rachaputi et al. 2002).

The combination of results obtained from the aflatoxin survey and the APSIM modelling work (Chauhan et al. 2006 in these proceedings) can be used to draw some conclusions and make recommendations for future work related to aflatoxin minimisation in PNG:

1. In EHP, aflatoxin minimisation research should focus on post-harvest practices, while in Morobe Province, appropriate pre- and post-harvest practices should be developed to minimise aflatoxin in peanuts.
2. Pre-harvest aflatoxin risk can be minimised by avoiding sowings in ‘high risk’ periods, as identified by the APSIM peanut model scenario analyses.
3. Pre-cleaning of extraneous matter and poor quality pods before storage, and segregation of kernels before processing, can significantly reduce aflatoxin contamination in processed samples. Inappropriate practices such as re-wetting the product should be discouraged.
4. Aflatoxin awareness and minimisation programs should be developed and implemented at grower, processor and consumer levels.

PNG, like many other countries, is a signatory to Codex Alimentarius (WHO/FAO documents that deal with food safety in traded commodities) and recognises the need to limit exposure of its population to aflatoxins. However, appropriate strategies to minimise economic and social consequences of aflatoxin risk need to be achieved for peanuts as well as for all other dietary staples which are prone to infection by the aflatoxin producing fungi. There is a strong need to build up the local capability for testing of food contamination, which determines the extent of risk and whether the regulations can be enforced.

All sections of the community should benefit from improved awareness about aflatoxin contamination in peanut and peanut products and ways to minimise the risk. Consumption of aflatoxin-free peanuts should improve the nutritional status of the PNG population. We hope that the information generated by the survey will assist the PNG government and private agencies to develop appropriate policies aimed especially at long-term improvement in health of poorer sections of the PNG community.

References

Chauhan Y., Rachaputi Rao C.N., Wright G., Kuniata L., Ramakrishna A., Tomda Y. and Geob T. 2006. Assessing the potential for rainfed peanut production in Papua New Guinea using crop modelling approaches. These proceedings.

Cole R.J., Dorner J.W. and Holbrook C.C. 1995. Advances in mycotoxin elimination and resistance. Adances in peanut science. (Eds H.E. Pattee and H.T. Stalker) pp. 456–474. Stillwater, OK: American Peanut Research and Education Society Inc.

Cole R.J., Sanders T.H., Dorner J.W. and Blankenship P.D. 1989. Environmental conditions required to induce preharvest aflatoxin contamination of groundnuts: summary of six years' research. In 'Proceedings of the International Workshop on Aflatoxin Contamination of Groundnut' ICRISAT 1987. (Ed. S.D. Hall) pp. 279–287. ICRISAT Center: Patancheru, India.

Dickens J.W. and Khalsa J.S. 1967. Windrow orientation and harvesting damage to peanuts. Oleagineux 22, 741–746.

Food and Drug Administration (FDA) 1995. Sec 555.400 Foods-adulteration with aflatoxin (CPG 7120.26). Internet: http://www.fda.gov/ora/compliance_ref

Harkness C., McDonald D., Stonebridge W.C., A'Brook J. and Darling H.S. 1966. The harvesting, handling and storage of crops in relation to development of toxic fungi, with special relation to groundnut production in tropical Africa. Food Technology 20, 72–78.

Henry S.H., Bosch F.X., Troxell T.C. and Bolger P.M. 1999. Reducing liver cancer-global control of aflatoxin. Science 286, 2453–2454.

Holaday C.E. and Passwater R.A. 1969. Minicolumn chromatography and fluorometry. Fluorescence News 4, (2).

NageswaraRao Rachaputi, Wright G.C. and Krosch S. 2002. Management practices to minimise pre-harvest aflatoxin contamination in Australian peanuts. Australian Journal of Experimental Agriculture 42, 595–605.

Van Egmond H.P. 1995. Mycotoxins: regulations quality assurance and reference materials. Food Additives and Contaminants 12, 321–330.

Wemin J.M. and Geob T. 2004. Peanut production, utilisation and marketing in Papua New Guinea: a peanut farmer survey. Project report for ACIAR Project ASEM 2001/055. National Agricultural Research Institute, Aiyura, Papua New Guinea.

Williams J.H., Phillips T.D., Jolly P.E., Stiles J.K., Jolly C.M. and Agarwal D. 2004. Human aflatoxicosis in developing countries: a review of toxicology, exposure, potential health consequences, and interventions. American Journal of Clinical Nutrition 80, 1106–1122.

Appendix 1

ACIAR PEANUT PROJECT ASEM/2001/055

AFLATOXIN SURVEY

INFORMATION SHEET FOR MARKET SAMPLING

1 Market

Province/Region	
Name of Market	

2 Sample collection summary

Officer	
Date collected	
Sample CODE	

3 Basic history of sample

Is the Seller Farmer/Grower or Retailer?	
Name of Seller	
Village/Settlement	
District	
Variety (name if grower/seller knows)	
Date Planted (grower to provide if known)	
Date harvested (if grower is selling)	
Date peanuts were bought (if reseller is selling)	
Estimated days or weeks after harvest	
Origin of peanuts (if samples collected from retailer)	
Post harvest practices:	
i. Were peanuts washed after harvested?	
ii. Were dried peanuts wet to keep pods fresh?	
iii. **Drying** methods used?	
iv. **Transport** mode or method used?	
v. **Storage** method used (How long? Where?)	
vi. Estimated time duration to finish selling all peanuts?	
vii. Comments on condition of sample when obtained (eg moulds, insect damage)	

4 Quantity

At least 1 kg kernel or 2 kg nut in shell per sample are required.

Quantity	
Amount (PGK)	

Note:

1 If you have more comments, use the back page of the information sheet.

2 CODE: GKA = Goroka Market, NCD = Gordons Market, KOK = Kokopo Market, RAM = Ramu Market, UMI = Umi Market, First 3 letter of month, D = Dry sample, F = Fresh sample, Number of samples = 1, 2, 3. e.g. GKA/SEP/D/1

Peanuts for sale at the 40-mile market in the Markham Valley, Papua New Guinea

Selection of peanut varieties adapted to the highlands of Papua New Guinea

A. Ramakrishna[1], Johnny M. Wemin[1], Timothy Geob[1], Yanding Tomda[1], Rao C.N. Rachaputi[2] and G.C. Wright[2]

[1]*National Agricultural Research Institute, Aiyura, Papua New Guinea; email: a.ramakrishna@nari.org.pg*

[2]*Department of Primary Industries and Fisheries, PO Box 23, Kingaroy, Queensland 4610, Australia*

Abstract

Peanut is an important cash crop for small landholders in the highlands of Papua New Guinea because it has a high market value, short time to maturity and is easy to transport compared to popular crops like sweet potato. Peanut is mainly grown as a subsistence crop either in rotation with sweet potato or cassava or as a mixed crop with maize. Peanut growers in the Eastern Highlands Province are keen to intensify peanut cultivation if the seeds of high yielding varieties are available. However, there has been little research effort on evaluation and introduction of new peanut varieties adapted to highland conditions. During 2003–05, field trials were conducted at the main highlands research program of the National Agricultural Research Institute, Aiyura, to identify high-yielding peanut cultivars from a wide range of peanut germplasm introduced from the International Crops Research Institute for the Semi-Arid tropics (ICRISAT), India. The germplasm was grouped into short- and medium-duration types based on prior information about the time to maturity and evaluated in two separate trials. At Aiyura, short-duration cultivars matured at 126–134 days and yielded 3.5–4.8 t ha^{-1}, compared to medium-duration cultivars which took 150–164 days to mature and produced yields of 2–3 t ha^{-1}. However, some of the medium-duration cultivars had large kernel size (up to 0.8 gm per kernel), which could be attractive to the snack food niche market. Short-duration cultivars ICGV 93058, 94049, 93143, 96470, 96466 and 94361, and medium-duration cultivars ICGV 94043, 93115, 94113 and 96073, were found to be superior to local check varieties. The selected cultivars will be further evaluated in farmer fields before possible release for production in the highlands.

Introduction

Production of peanut (*Arachis hypogaea* L.) in the highlands of Papua New Guinea (PNG) dates back to the early 1950s by the European and Seventh Day Adventist Missions (Gibson 2001). One of the introduced varieties named 'Seventh Day Peanut' is still cultivated in a few pockets in the highlands. Currently, peanut is being grown widely in the highlands, up to 2500 m above mean sea level. The crop is mostly grown on small blocks of land once or twice a year with a few farmers cultivating three times a year. The main cropping season is November to February. The highland farmers consider peanut as a lighter crop to transport to markets compared to bulky and perishable tuber crops like sweet potato *(Ipomoea batatas)*. Peanuts generate a major portion of the family income after coffee *(Coffea arabica)* with a selling price of K40–70 for a 28–30 kg bag in the local markets (Wemin and Geob 2004).

The subsistence production of peanut in the highlands of PNG is characterised by the diversity of the local cultivars. The reasons for this diversity are complex and probably include (i) the selection of new cultivars derived from seed mixture, (ii) the cultural isolation of growers, (iii) taste preferences of growers and consumers, and (iv) specific adaptation of varieties. Most commonly grown peanut cultivars are Virginia Bunch and White Spanish types, and Hagen or Goroka shorty (with two- or three-seeded varieties). These varieties mature in about 16–17 weeks from planting. There has been no introduction of new varieties into the highlands for many decades. Farmers are interested in high-yielding improved

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

varieties but the non-availability of seed is the major limitation. As a part of the ACIAR project (ASEM 2001/055) a wide range of short- and medium-duration elite peanut varieties was introduced from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India, for evaluation in PNG environments. The new varieties were evaluated at the National Agricultural Research Institute (NARI), Aiyura to assess their performance and identify the high-yielding cultivars suitable for production and marketing in the highlands.

Materials and methods

Experimental site

The trials were carried out at the experimental farm of the main highlands program, NARI, Aiyura, (6°9'S and 145°55'E; 1644 m above mean sea level). The soil is a clay loam with a pH of 6.0, very low in phosphorus (Olson P 2.2 mg kg soil^{-1}), low potassium (0.66) and adequate nitrogen (0.46%). The experimental block was well ploughed and disc harrowed to make a suitable seed bed. No fertiliser was applied. The seeds were hand-dibbled at 5–7 cm depth, in furrows opened with hand hoes.

Peanut varieties

The ACIAR project facilitated the introduction of 46 ICRISAT Groundnut Variety (ICGV) accessions for evaluation in PNG environments. The varieties were grouped into short- and medium-duration types, based on the time to maturity. Accordingly, two separate field trials, i.e. short (SD) and medium duration (MD) varietal trials, were conducted during each of the 2003, 2004 and 2005 growing seasons. However, based on the observations made in the first season, some varieties were interchanged between the two trials (described below).

Short-duration peanut varietal trial

The short-duration trial was laid out as a randomised complete block design with three replications, during the 2003, 2004 and 2005 growing seasons. The trial had 27 varieties (24 ICGVs and 3 local checks) in the 2003 season and 26 varieties (23 ICGVs and 3 local checks) in the 2004 and 2005 seasons (Table 1). Two varieties, viz. ICGVs 93058 and 94049, which were in the medium-duration maturity group in the first season were shifted to the short-duration group in the next two seasons. The planting and harvesting dates are presented in Table 2. Plot size was 4 × 4 m with spacing of 40 cm between the rows and 10 cm between the plants within a row. The crops were grown under rainfed conditions with no protection against pests or diseases except for seed treatment with Captan® at 3 g kg^{-1} seed at the time of planting. Plants were randomly tested for maturity starting 90 days after planting at 10-day intervals and the varieties were harvested when >80% of pods showed blackening of the internal shell wall. In each plot final yield data were collected from the middle two rows (ground area of 1.6 m^2). The harvested pods were sun-dried in the field for at least 5 days before recording the weight. Shelling per cent, 100-seed weight and total biomass were recorded for all the varieties as described under the data analysis section.

Table 1. Short-duration peanut varieties evaluated at the NARI Research Station, Aiyura, Papua New Guinea during the 2003, 2004 and 2005 growing seasons

Accession (ICGV nos)	
96466	95322
95179*	95245
95271	94350
94358	95299
94361	95278
96470	95319
94037*	94040
95244	95256
94299	95248
95290	92029*
94357	96469
94016*	93058***
94341	94049***
Ex.Aiyura (C)	Topo (C)****
NG 454 (C)*	Ex.Markham (C)***
Ex.Keravat (C)**	

* First season only; ** first and second season only; *** second and third season only; **** third season only.

Table 2. Planting and harvesting dates of short-duration peanut varietal trials conducted at Aiyura, Papua New Guinea

Season	Date of planting	Date of harvesting	Crop duration (days)
First	25 Feb 2003	05 June 2003	134
Second	12 Nov 2003	17 March 2004	126
Third	08 Dec 2004	25 April 2005	131

Medium duration peanut varietal trial

The medium-duration variety trial was laid out as a randomised block design with three replications, with 23 varieties (20 ICGVs and 3 local checks) in the 2003 season; 19 varieties (17 ICGVs and 2 local checks) in 2004 and 24 varieties (22 ICGVs and 2 local checks) in the 2005 season (Table 3). The plot size and spacing were similar to those of the SD trial. Planting and harvesting dates and crop duration are shown in Table 4. The crops were grown under rainfed conditions with no protection against pests or diseases, except for seed treatment with Captan® at 3 g kg^{-1} seed at the time of planting.

Table 3. Medium-duration peanut varieties evaluated at the NARI Research Station, Aiyura, Papua New Guinea during the 2003, 2004 and 2005 growing seasons.

Accessions (ICGV nos)	
93143*	96066
94043	96110
94049*	96100
94113	93139
93115	92160
96073	93143
95163	94043
93058*	92029**
96081	94016**
93123	94037**
96107	95179**
94215	96234**
96108	K 2 I (C)
95165	K 3 (C)
95172	NG 454*

* First season only; ** third season only.

Table 4. Planting and harvesting dates of medium-duration peanut varietal trials conducted at Aiyura, Papua New Guinea

Season	Date of planting	Date of harvesting	Crop duration (days)
First	26 Feb 2003	09 July 2003	164
Second	13 Nov 2003	06 April 2004	146
Third	09 Dec 2004	16 May 2005	159

In all three seasons, there was a moderate to severe incidence of foliar disease (mainly late leaf spot), with some leaf rust occurring towards the end of the season (data not presented).

Data analysis

In both the trials, the data on pod, kernel weight and oven-dry weight of vegetative parts (leaf + stem) were recorded for each plot and the crop parameters, viz. total biomass, shelling per cent, harvest index, and 100-seed weight, were computed as follows.

Total biomass = vegetative + pod dry weight

Shelling percentage = (kernel weight/pod weight) × 100

100-seed weight = weight of 100 sound mature kernels

The data were analysed using Genstat Version 5.

Results and discussion

Climate

The long-term mean annual rainfall of Aiyura is about 2156 mm and most of it occurs between October and May as a result of the northwest monsoon. February is the wettest month with a mean rainfall of about 280 mm, while the June to September period is

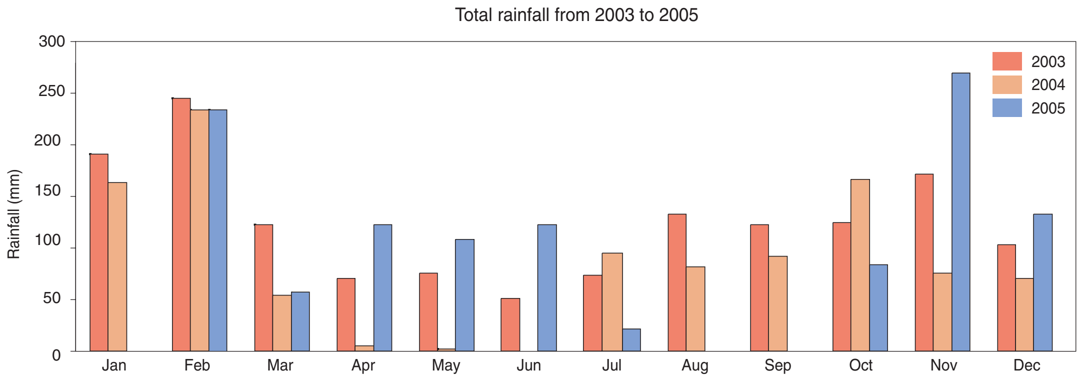

Figure 1. Rainfall distribution at the Aiyura, Papua New Guinea site during the years 2003, 2004 and 2005

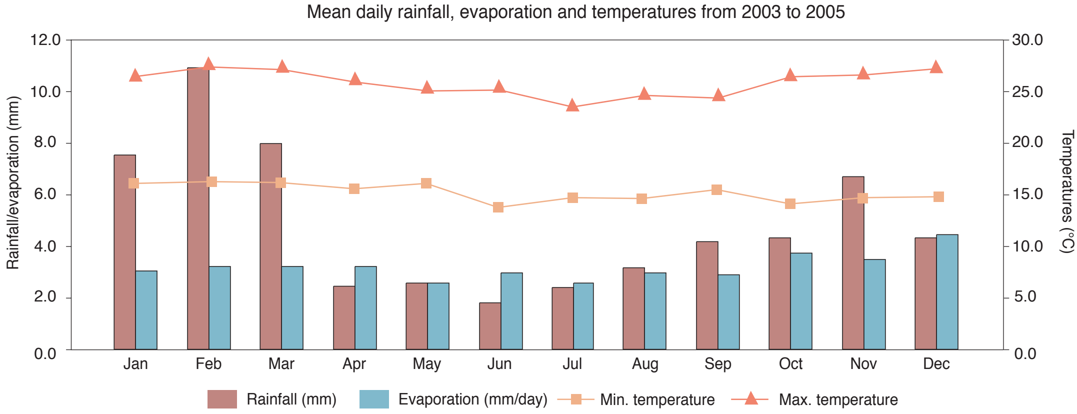

Figure 2. Mean daily rainfall, evaporation and air temperatures at Aiyura, Papua New Guinea during the years 2003, 2004 and 2005

relatively dry and receives a mean rainfall of about 90 mm per month. The evapotranspiration (class A pan) exceeds the total rainfall between April and July. The daily mean temperature ranges from 12°C to 24°C. A summary of weather during the trial periods of 2003, 2004 and 2005 is presented in Figures 1 and 2. The total in-season rainfall was 850 mm, 1100 mm and 1035 mm for the short-duration trial and 900 mm, 1215 mm and 1155 mm for the medium-duration trial, for the 2003, 2004 and 2005 growing seasons, respectively. The total rainfall was adequate for a typical peanut crop, while the distribution of rainfall varied between the seasons resulting in significant variation in the yields between the three seasons. The mean solar radiation ranged from 15 to 20 MJ m^{-2} d^{-1} during the growing seasons.

The APSIM peanut model was used to estimate the seasonal changes in plant-available soil water based on the daily weather data during the 2003, 2004 and 2005 growing seasons and soil properties at the Aiyura research station (Figure 3). The model output showed that the soil water was close to field capacity (120 mm) up to 100 days after sowing in the 2003 and 2005 seasons, while 2004 experienced mild droughts throughout the growing period. After 100 days after sowing (DAS), the pattern of plant-available water differed between the seasons. In 2003, there was a prolonged water deficit period from 100 DAS, which was relieved by heavy rainfall at 150 DAS. During this season, the short-duration types experienced the end-of-season drought before harvest whereas the medium-duration types had time to recover from the water deficit. The 2004 (second) season was characterised by intermittent mild dry spells, although the plant-available water was adequate (>80 mm) throughout the season to support crop growth.

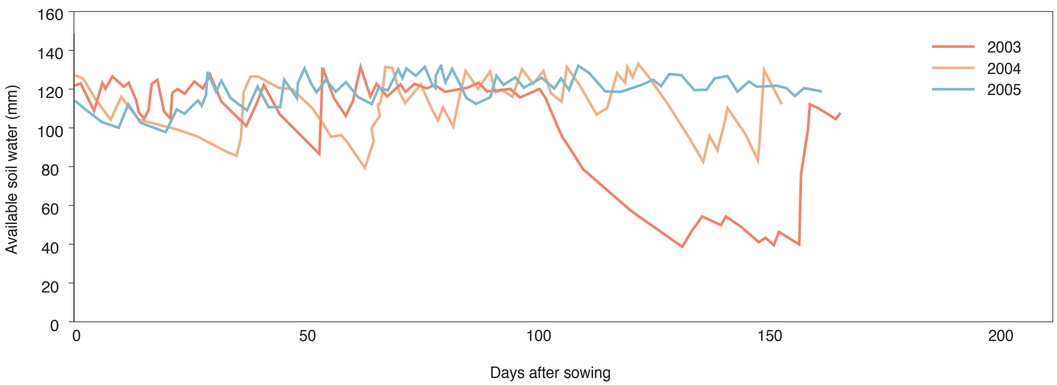

Figure 3. Seasonal changes in plant-available soil water at Aiyura, Papua New Guinea during the 2003, 2004 and 2005 growing seasons as simulated by the APSIM peanut model

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

During the 2005 (third) season, the soil was at field capacity throughout the season, which resulted in frequent waterlogging and prolonged cloudy periods. The simulation of dynamic changes in plant-available water is an effective way of value adding the daily data on climate and soil properties and using it to interpret variation in crop growth within and across seasons.

Short-duration trial

The highest yields were obtained in the second (2004) season followed by the first (2003) and the third (2005) season. The poor yields in the third season could be due to heavy rainfall and prolonged cloudy periods resulting in poor crop and pod growth. The yields were highest in the second season, which could be ascribed to optimum planting date and thereby congenial climatic conditions throughout the growing period (Tables 5–7).

Under Aiyura conditions, the crop duration of short-duration varieties ranged from 126 to 134 days. Varieties differed significantly each season, with pod yields ranging from 1.2 to 3.2 t ha^{-1} in the first season (Table 5), 1.5 to 7.6 t ha^{-1} in the second season (Table 6), and 0.3 to 1.9 t ha^{-1} in the third season (Table 7). The yields of 60% of the ICGV lines were greater than the average yield of the local varieties, indicating higher yield potential of new peanut varieties under highland conditions. As a result of change in the varietal composition (after the 2003 trial), there were 19 common varieties in the 2003, 2004, and 2005 trials and 23 varieties common in the 2004 and 2005 season trials.

Although the yields were much lower in the 2005 season, there was a significant positive correlation (R = 0.49**) between pod yields of the 2004 and 2005 season trials (Figure 4) suggesting consistency in varietal ranking between the two seasons. However,

Table 5. Pod yield, shelling per cent and 100-seed weight of short-duration varieties grown at Aiyura, Papua New Guinea during February–June, 2003

Genotype	Pod yield (t ha^{-1})	Shelling %	100-seed wt (g)
ICGV 96466	3.2	74	64
ICGV 95179	3.2	63	80
ICGV 95271	2.9	74	48
ICGV 94358	2.7	77	47
ICGV 94361	2.7	76	45
ICGV 96470	2.6	72	61
Ex.Aiyura	2.5	71	59
ICGV 94037	2.4	64	49
ICGV 95244	2.3	72	42
ICGV 94299	2.3	75	41
ICGV 95290	2.3	79	45
ICGV 94357	2.2	68	42
ICGV 94016	2.1	67	74
NG 454	2.0	72	54
ICGV 94341	1.9	74	37
ICGV 95322	1.9	74	31
ICGV 95245	1.9	66	41
ICGV 94350	1.9	74	40
ICGV 95299	1.9	74	42
ICGV 95278	1.9	76	46
ICGV 95319	1.8	69	43
Ex. Keravat	1.8	66	56
ICGV 94040	1.8	72	62
ICGV 95256	1.3	71	38
ICGV 95248	1.2	70	31
ICGV 92029	1.1	67	52
ICGV 96469	0.6	64	38
SE	0.36	4.9	4.2
CV%	16.9	6.9	8.6

Table 6. Pod yield, shelling per cent and 100-seed weight of short-duration varieties grown at Aiyura, Papua New Guinea during Nov 2003–March 2004

Genotype	Pod yield (t ha^{-1})	Shelling %	100-seed wt (g)
ICGV 93058	7.6	50	35
ICGV 94049	6.7	54	38
ICGV 93143	6.6	52	32
ICGV 96466	5.4	62	38
ICGV 96470	4.4	61	37
ICGV 95322	3.9	60	27
ICGV 96469	3.9	39	28
ICGV 94040	3.8	41	28
ICGV 95319	3.8	58	29
ICGV 94299	3.4	58	34
ICGV 95299	3.3	60	28
Ex-Aiyura	3.3	57	42
ICGV 95271	3.1	57	28
ICGV 95278	2.8	56	34
ICGV 95290	2.7	61	29
ICGV 94358	2.6	62	31
ICGV 95244	2.5	47	31
Ex-Markham	2.4	57	36
ICGV 95256	2.3	53	32
ICGV 94350	2.3	58	25
ICGV 94357	2.2	54	30
ICGV 94361	2.1	55	28
Ex-Keravat	1.8	49	37
ICGV 95245	1.6	50	24
ICGV 94341	1.6	65	23
ICGV 95248	1.5	56	24
SE	1.82	9.2	4.9
CV%	51.3	16.7	15.8

Table 7. Pod yield, shelling per cent, and 100-seed weight of short-duration varieties grown at Aiyura, Papua New Guinea during Dec 2004–April 05

Genotype	Pod yield (t ha^{-1})	Shelling %	100-seed wt (g)
ICGV 93058	1.92	64	54
ICGV 94049	1.65	70	50
ICGV 93143	1.56	67	48
ICGV 94361	1.32	76	40
ICGV 96466	1.29	71	45
ICGV 96469	1.27	65	39
ICGV 94350	1.09	77	36
ICGV 95245	1.07	71	35
ICGV 95290	1.02	77	37
ICGV 95278	0.88	72	46
ICGV 95256	0.81	74	33
ICGV 96470	0.80	73	47
ICGV 95319	0.69	71	29
ICGV 95322	0.69	71	25
Topo	0.69	75	36
ICGV 94299	0.68	75	37
ICGV 94040	0.63	61	38
ICGV 95244	0.60	70	36
ICGV 95271	0.56	70	34
ICGV 94357	0.54	70	28
ICGV 94341	0.50	75	27
Ex.Aiyura	0.49	67	36
Ex.Markham	0.41	69	30
ICGV 95299	0.38	71	24
ICGV 94358	0.30	77	29
ICGV 95248	0.27	73	23
S E	0.31	3.06	6.2
CV%	36	4.3	17.1

Table 8. Pod yield, shelling percentage and 100-seed weight of medium-duration varieties grown at Aiyura, Papua New Guinea during February–July, 2003

Genotype	Pod yield (t ha^{-1})	Shelling %	100-seed wt (g)
ICGV 93143	5.56	67	61
ICGV 94043	5.18	72	63
ICGV 94049	4.99	75	68
ICGV 94113	4.11	73	54
ICGV 93115	4.03	68	75
ICGV 96073	3.90	61	72
ICGV 95163	3.74	63	78
ICGV 93058	3.69	67	92
ICGV 96081	3.39	64	77
Keravat 3	3.32	70	59
ICGV 93123	3.29	72	59
Keravat 2	3.20	73	48
ICGV 96107	3.17	63	104
ICGV 94215	2.96	64	79
ICGV 96108	2.95	64	82
ICGV 95165	2.90	62	90
ICGV 95172	2.66	63	83
ICGV 96066	2.65	63	76
ICGV 96110	2.60	63	88
ICGV 96100	2.51	63	81
NG 454	2.47	73	55
ICGV 93139	2.42	68	56
ICGV 92160	1.64	64	62
Mean	3.36	66.9	72.3
SE	0.69	2.6	6.2
CV%	20.7	4	8.6

such a correlation was not observed in the 2003 season's data suggesting a genotype × environment interaction for pod yield.

Based on the performance of the 19 common varieties over the three seasons, the varieties ICGV 93143 (4.6 t ha^{-1}), ICGV 94049 (4.4 t ha^{-1}), ICGV 93058 (4.4 t ha^{-1}), ICGV 96466 (3.3 t ha^{-1}) and ICGV 96470 (2.6 t ha^{-1}), showed superior performance compared to the highest-yielding local variety Ex. Aiyura (2.1 t ha^{-1}). The local variety ex-Keravat yielded lowest among the checks (1.8 t ha^{-1}).

Highly significant differences (P<0.01) amongst varieties were observed in the crop parameters such as shelling per cent, 100-seed weight and harvest index in all seasons. The variety ICGV 96466 recorded the highest mean harvest index (0.75) and 100-seed weight of 51 g, with acceptable yield levels (3.3 t ha^{-1}) suggesting its adaptability to highland conditions.

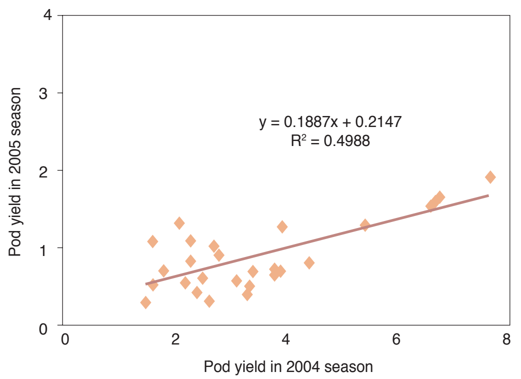

Figure 4. Relationship between pod yields of short-duration varieties grown at Aiyura, Papua New Guinea during the 2004 and 2005 seasons

Medium-duration trial

The pod yields in the medium-duration trials decreased progressively from first to third season (Tables 8–10) with the trial mean yields being 3.3 t ha^{-1}, 1.2 t ha^{-1} and 0.5 t ha^{-1} in the first, second and third seasons, respectively. Generally, medium-duration varieties produced fewer pods and lower yields under Aiyura conditions. However, some of the medium-duration varieties had large kernel size (100-seed wt of 60–100 g).

Poor yields of medium-duration varieties at Aiyura could be due to cooler temperatures resulting in a longer growing season. It is possible that the crop duration allowed for the medium-duration trial may be insufficient to satisfy the thermal time requirement of the genotype (Leong and Ong 1983). Longer crop duration also meant high probability of the crop being exposed to multiple stresses including foliar diseases. Although medium-duration cultivars in general had lower yields than short-duration cultivars in the highland environments, the large kernel size of some of the medium-duration cultivars could attract a high value in the snack food market.

The pooled analysis of 17 medium-duration varieties which were common across the three seasons showed that ICGV 94043 (3.1 t ha^{-1}), ICGV 93115 (2.1 t ha^{-1}), ICGV 94113 (1.8 t ha^{-1}) and ICGV 96073 (1.7 t ha^{-1}) had significantly out-yielded the local check varieties. Although some varieties (for example ICGV 96107) had large kernel size (100-seed weight of up to 100 g), their yields were comparable to local check varieties, suggesting scope for introducing varieties for special niche markets. The cultivars ICGV 94043 and ICGV 94113 also recorded moderate kernel size (100-seed weight of about 52 g) and harvest index (0.42–0.5). The performance of local varieties (Keravat 2 and 3) was very poor (ranging from 0.4 to 1.3 t ha^{-1}) across three seasons.

The yields of medium-duration varieties were the highest in the 2003 season followed by the 2004 and 2005 seasons, respectively. Higher yields in 2003

Table 9. Pod yield, shelling percentage and 100-seed weight of medium-duration varieties grown at Aiyura, Papua New Guinea during the November 2003–April 2004 season

Genotype	Pod yield (t ha^{-1})	Shelling %	100-seed wt (g)
ICGV 94043	2.70	64	43
ICGV 96066	2.71	62	55
ICGV 93139	1.55	64	37
ICGV 96081	1.68	54	48
ICGV 96073	1.61	52	40
ICGV 95163	1.35	56	49
ICGV 93115	1.33	51	40
ICGV 95165	1.29	50	45
ICGV 96108	1.07	61	55
ICGV 95172	1.03	55	42
ICGV 96110	1.03	52	56
ICGV 93123	0.90	60	42
ICGV 94215	0.81	52	52
ICGV 92160	0.76	52	54
ICGV 96107	0.63	46	60
ICGV 94113	0.44	63	37
Ex-Keravat 3	0.45	56	36
Ex-Keravat 2	0.41	60	30
ICGV 96100	0.32	54	50
Mean	1.16	56.3	46
SE	0.39	5.2	7
CV%	34.2	9.2	15

Table 10. Pod yield, shelling percentage and 100-seed weight of medium-duration varieties grown at Aiyura, Papua New Guinea during Dec 2004–May 05

Genotype	Pod yield (t ha^{-1})	Shelling %	100-seed wt (g)
ICGV 94043	1.39	71	51
ICGV 93115	1.01	64	57
ICGV 96066	0.96	67	65
ICGV 95172	0.83	68	70
ICGV 94113	0.65	70	53
ICGV 96073	0.61	60	49
ICGV 96110	0.59	64	67
ICGV 95165	0.58	62	61
ICGV 92160	0.55	62	66
ICGV 96107	0.49	66	63
ICGV 94037	0.46	66	47
ICGV 95163	0.45	68	58
ICGV 94016	0.41	64	61
ICGV 93139	0.40	74	44
ICGV 96100	0.40	64	54
ICGV 96234	0.36	66	61
ICGV 96081	0.36	67	59
ICGV 93123	0.34	71	48
ICGV 94215	0.33	69	47
ICGV 96108	0.29	63	46
ICGV 95179	0.24	69	38
K3	0.15	69	35
K2	0.13	71	29
ICGV 92029	0.13	66	33
Mean	0.50	66.7	52.6
S E	0.14	NS	6.30
CV%	28.6	5.9	12.0

could be due to a longer growing season (2 weeks longer in 2003 compared to the 2004 and 2005 seasons, Table 4). However, poor adaptation of medium-duration varieties to the highland environment could be due to a number of factors. Crop duration is a major yield determining factor in peanut, and cooler temperatures lead to a longer growing season. The APSIM-peanut model simulation has shown that the medium-duration cultivars required 4–6 weeks longer time (over and above the actual harvest) in the Aiyura environment (Chauhan et al. these proceedings). Thus, the premature harvests in years 2004 and 2005 combined with incidence of foliar diseases towards the end of the season could have resulted in poor yields and immature pods (as indicated by a lower harvest index (data not presented) and shelling per cent). Further, prolonged rainy periods (and hence low radiation and waterlogging conditions) would also have a severe effect on nodulation, pod growth and development. Foliar diseases during the pod filling period would further affect pod filling resulting in lower shelling and poor kernel growth.

Conclusions

The peanut varietal trials conducted at Aiyura during the 2003–2005 seasons have demonstrated that it is possible to harvest pod yields of up to >4.5 t/ha under highland conditions. The yield performance data showed that short-duration peanut varieties may be more suitable for highland conditions than are medium- or long-duration varieties. Under highland conditions, the short-duration varieties required up to 130 days to mature while the medium-duration varieties required more than 160 days. However, medium-duration varieties had a larger kernel size than the short-duration types, suggesting scope for these varieties in the snack food niche market.

There was a significant variation among varieties for tolerance to foliar diseases however; the most tolerant varieties were not necessarily high yielders due to genotypic difference in partitioning of dry matter to pods.

A number of short- and medium-duration peanut varieties have out-yielded the local checks, indicating good potential for improving peanut production in the highlands. The most promising short-duration cultivars were ICGVs 93058, 94049, 93143, 96470, and 96466, which showed a productivity of 3.35–4.74 t ha^{-1}; and medium-duration cultivars ICGVs 94043, 93115, 94113, and 96073 had mean pod yields of 2.0–3.1 t ha^{-1}. The yields of local check varieties ranged from <0.5 t/ha to 2 t/ha.

A highland farmer from six mile site, Kainantu, Papua New Guinea showing the yield from an improved (right) and a local variety (left).

There is a need to further assess the performance of the selected varieties on farmers' fields before recommending their general cultivation by farmers in the highlands.

Acknowledgments

We gratefully acknowledge the help from a number of technicians at NARI, Aiyura in implementing the field trials. We acknowledge the support of Dr Hari Updhyaya, ICRISAT in developing a technical work plan and monitoring field trials. The research work has been funded by the Australian Centre for International Research (ACIAR).

References

Chauhan Y., Rachaputi R.C.N., Wright G., Kuniata L., Ramakrishna A., Yanding T. and Geob T. 2006. Assessing the potential for rainfed crop production in Papua New Guinea using crop modelling approaches. These proceedings.

Gibson J. 2001. The economic and nutritional importance of household food production in PNG. In 'Food security in Papua New Guinea', eds Bourke R.M., Allen, M.G. and Salisbury J. ACIAR Proceedings 99, pp 37–44.

Leong S.K. and Ong C.K. 1983. The influence of temperature and soil water deficit on the development and morphology of peanut (*Arachis hypogaea* L.). Journal of Experimental Botany 34, 1551–1561.

Wemin J.M. and Geob T. 2004. Peanut production, utilisation and marketing in Papua New Guinea: a peanut farmer survey. Project report for ACIAR Project ASEM 2001/055. National Agricultural Research Institute, Aiyura, Papua New Guinea; p 15.

Peanut in the Papua New Guinea highlands: production, problems and prospects

A. Ramakrishna, Johnny M. Wemin, Timothy Geob and Yanding Tomda

National Agricultural Research Institute, Aiyura, PO Box 210, Eastern Highlands Province, Papua New Guinea; email: a.ramakrishna@nari.org.pg

Abstract

Peanut is a major income earning crop for the smallholder semi-subsistence farmers in the highlands of Papua New Guinea. Women in particular recognise the potential and devote much time and effort to the production and marketing of peanuts. Sweet potato is the major staple food in the highlands so there is a need for a supplementary protein-rich food. Peanut could provide a healthy alternative to animal protein as it is rich in protein, carbohydrates, essential amino acids and vitamins and thus could contribute to nutritional security of highland populations. Being a leguminous crop, peanut contributes to maintenance of soil fertility through biological nitrogen fixation. Adoption of modern peanut production and processing technologies for local and domestic marketing also enhances employment opportunities in rural areas. Concerted efforts are required to increase peanut production and productivity and thereby economic security to small landholding communities.

Peanut yields are low — around 0.6–1.0 t ha^{-1} — due to lack of access to improved varieties and appropriate management practices. The varietal trials conducted at Aiyura have led to selection of promising varieties adapted to highland conditions. However, there is an urgent need to develop integrated varietal and management practices and extend these technologies to smallholders.

This paper describes current peanut production practices in the highlands and also presents results from field trials conducted to assess effects of management practices such as plant population density, seed dressing, storage and fertilisers on peanut.

Introduction

The highlands region of Papua New Guinea (PNG) is home to nearly two-thirds of the total population (about 3 million people) and occupies a land area of 51,175 sq km (13.5% of the total land area in PNG). The population growth rate in the Eastern Highlands Province (EHP) is higher (3.6% per year) than the national population average (2.7% per year) (Keig 1999). Most of the farming communities in the highlands consist of smallholder, semi-subsistence farmers who rely on their own food production systems, some cash crops and live in remote areas with poor market access (Allen et al.1995). While population growth in the EHP is significant, there has been little expansion of agricultural land (McAlpine et al. 2001), which implies significant intensification of agriculture within existing cropping areas. Crop intensification in the highlands is occurring through a combination of shorter fallows, longer cropping periods and using short and efficient food and cash crops such as peanut (Hanson et al. 2001).

Peanut (*Arachis hypogaea* L.) has been a popular crop in the highlands and its history dates back to early European and missionary contacts. In the highlands of PNG peanut is grown up to >2500 m above sea level. Peanut is an important cash crop among settlers, peri-urban gardeners and remote villagers. Farmers in remote villages appreciate peanuts as a crop which is easy to transport to the markets compared to other bulky and perishable crops such as sweet potato (*Ipomoea batatas*), Irish potato (*Solanum tuberosum*), banana (*Musa* spp.), yam (*Dioscorea* spp.), and taro (*Colocasia esculenta*). A farmer survey conducted in four major peanut growing regions in PNG established peanut as one of the top five popular income generating crops (Wemin and Geob 2004). Peanut generates a major portion of the family income in the highlands, after coffee. Women in particular recognise the potential of the crop and devote much time and effort into

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

the production and marketing of peanuts. However, its production has been low (0.6 t ha^{-1} in the EHP to 1.5 t ha^{-1} in Mt Hagen) and erratic (Wemin and Geob 2004).

In order to enhance peanut production in the highlands it is necessary to identify high-yielding peanut varieties adapted to highland conditions and develop cost-effective management technologies. These varietal and management technologies need to be effectively extended to peanut growers to enhance economic returns from the existing primary production systems. This paper presents the results from a series of experiments conducted as a part of the ACIAR project ASEM/2001/055, 'Improving yield and economic viability of peanut production in Papua New Guinea and Australia using integrated management and modelling approaches', and describes the current status of crop husbandry practices in the highlands and simple management practices required to sustain peanut production in the EHP.

Soils in Eastern Highlands Province

Soils in the highlands are generally moderately acidic (4.5–6.0 pH), low to adequate in nitrogen (0.32–0.46%), low in potassium (0.66) and very low in phosphorus (Olson P 2.2 mg kg $soil^{-1}$).

Climate

A detailed description of typical climatic conditions in the highlands is described by Ramakrishna et al. (p. 28 in these proceedings). February is the wettest month with a mean rainfall of about 280 mm, while the June to September period is relatively dry and receives a mean rainfall of about 90 mm per month. Simulation of peanut yield scenarios based on long-term climate records has shown that temperature and rainfall in the EHP allow year-round production of peanut in the highlands (see Chauhan et al., p. 68 these proceedings). However, potential yields can only be realised when other biotic and abiotic constraints to production are removed by appropriate varietal and management practices.

Production practices

Land allocation and preparation

Land allocation is based on the importance of the crop as either a major source of food or an income earner. In the EHP more land is allocated to coffee as the main cash crop and sweet potato as the staple food. However, peri-urban farmers allocate a greater proportion of the cultivated land to peanuts due to market vicinity, high demand and short growing season compared to coffee.

Peanut is grown on a range of land topographies ranging from flat to steep slopes (up to 30°). Most farmers prefer to grow peanuts either on loam or silty loam soils. However, peanut is also grown on clay loam and sandy loam soils to a limited extent. The majority of farmers manually till their land using spades, hoes and bush knives. Preparation of land and making a proper seed bed is critical for crop establishment, pod development and effective weed control.

Planting season

In the highlands, favourable rainfall distribution and temperatures allow peanut production throughout the year. However, at the farmer level, planting of a peanut crop is dependent on the availability of production inputs, including seed material. Most peanuts are grown in the wet season (October to March) because of higher yields and better quality kernels compared to the dry season (May to September) crops. Peanut crop modelling approaches (see Chauhan et al., these proceedings) supported by some strategic field validation trials are needed to identify appropriate planting times to harness potential yields in the major growing regions of the highlands.

Seed source

More than 60% of peanut farmers purchase seed from the local market and the rest keep their own seeds (Wemin and Geob 2004). The cost of seed accounts for 15–20% of the total cost of peanut cultivation. Pre-cleaning of seeds (to discard extraneous matter including weed seeds and damaged ones) and proper seed treatment is important for achieving a good plant stand and high yields. Availability of pure and high-quality seeds is one of the major constraints in the highlands. There is no public or private agency to control quality of peanut seed material. Concerted efforts are needed by the provincial agricultural departments, research institutions and other stakeholders to develop appropriate procedures and checks for production and supply of high-quality seeds.

Rhizobium inoculation

Peanuts and other legumes can form symbiotic associations with soil bacteria of the genus *Rhizobium*. The bacteria infect the plant roots and proliferate in nodules where molecular nitrogen from the atmosphere is fixed (Dart 1977). The peanut plant, by itself, cannot fix nitrogen but the bacteroids in the nodule can fix atmospheric nitrogen under proper

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

cultural and nutrient conditions. Native peanut rhizobia are abundant in most peanut or legume crop-growing soils. Application of a *Rhizobium* inoculum has increased yields in very few instances. However, some researchers have observed differences in N fixation between host plants with a given *Rhizobium* strain and significant host × strain interactions (Wynne et al. 1978, 1980).

Inoculation with *Rhizobium* is a common practice in commercial peanut production in developed countries but not in PNG due to lack of knowledge and unavailability of commercial *Rhizobium* inoculums. Poor nodulation has been observed in most of the peanut fields surveyed in the highlands. This could occur for a number of reasons (such as waterlogging, prolonged overcast conditions, nutrient disorders and unfavourable host × strain interactions). Inoculation of peanut seeds with a proper culture of *Rhizobium* is advisable unless inoculated peanuts, cowpea, mung bean or lima beans or peas have been grown previously in the soil. Rhizobial death may also occur due to frequent and heavy rainfall and hence regular rhizobial inoculation may be necessary in highland conditions. However, before embarking on large-scale research on *Rhizobium*, it will be necessary to understand and demonstrate the importance of rhizobial inoculation by conducting simple field trials with and without inoculation. Trials are in progress to assess the role of *Rhizobium* inoculum in the current ACIAR peanut project.

Seed treatment

Soaking of peanut kernels overnight in water using plastic or aluminum containers for 24 hours prior to planting is a common practice in PNG. The damaged and shrivelled seeds that float are discarded. This method is viewed as security against pest and disease problems and for quick establishment of the crop. Pre-germinated seeds are planted on mounds, ridges or flat ground. Plant density is highly variable (>100 000 to 200 000 plants ha^{-1}) due to loss of viability or seedling mortality. The dead seedlings are continuously replaced with new seeds.

Field trials were conducted at the National Agricultural Research Institute, Aiyura and Keravat to study the effect of seed dressing with various combinations of pesticides on crop establishment and yield response. At both sites, the seed dressing treatments had significant effects on crop establishment, with emergence ranging from about 75% in the control, to 80–95% in seed treatment with Thiram. However, seed dressing treatments did not give significant differences in yields. Considering the costs and crop establishment responses, seed dressing with either 10% neem oil or a combination of captan + carbaryl at 1.5 g or captan at 3 g kg^{-1} seed or captan + thiram at 3 g kg^{-1} seed appear to be most cost-effective in the highlands. However, further studies with chemical and biopesticides are planned to identify environmentally friendly and cost-effective measures to manage seedling diseases.

Sowing and spacing

Proper crop establishment and optimum plant stand are critical for achieving high yields in peanut.

The current practice in PNG is to dibble the seeds at random. While this practice may not have any apparent drawbacks as far as crop emergence is concerned, the random planting may pose practical problems in intercultural operations, especially during weeding, topdressing or harvesting.

A row-spacing trial was conducted at Aiyura with two varieties (ICGVs 94358 and 95271) and four row-spacing treatments (30, 40, 60, and 90 cm). There were no varietal differences although there was a response to row spacing, with the pod weight being optimum at 60 cm (Figure 1). On-farm trials planned in the ACIAR project will compare farmer practice with the row planting method to demonstrate the advantage of planting in rows.

Fertilisation

As a legume, peanut can fix nitrogen from the atmosphere, however, it does require other nutrients for its growth and development. Most peanut soils in the highlands are relatively low in fertility and farmers do not usually apply inorganic fertilisers. An on-farm study was conducted to assess the fertiliser and plant density interaction in peanut with two varieties (a local

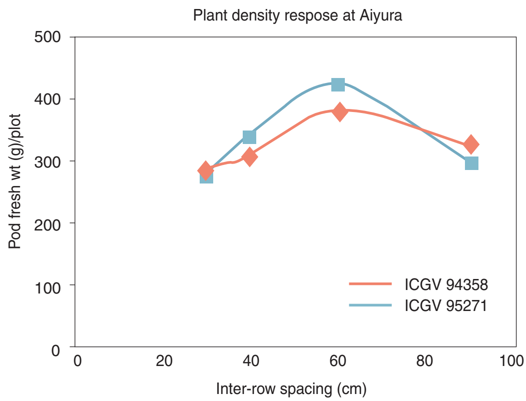

Figure 1. Plant density responses in peanut at Aiyura, Papua New Guinea (2003–04)

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

variety (Ex-Markham) and ICGV 95271). There were two fertiliser regimes, i.e. without fertiliser (F0) and with fertiliser (F1) and two density levels (100,000 and 250,000 plants ha^{-1}). The fertiliser treatment (F1) consisted of urea 20 kg N/ha as a top dressing and a foliar spray of iron, zinc, copper sulfate, urea mixture at 2 kg per 100 L during the pod filling period.

There was a positive yield response with the application of fertiliser in both varieties at both plant densities, although the yield levels were generally poor during the season (Table 1).

The soils of Aiyura, Goroka, and Mt Hagen are generally moderately acidic (pH 4.5–6.0), with low to adequate nitrogen (0.32–0.46%), low potassium (0.66%) and very low phosphorus (Olson P 2.2 mg kg soil^{-1}). Thus, application of phosphorus (P) becomes important for achieving optimum growth and yield of peanuts. Studies conducted elsewhere have clearly indicated that application of phosphate fertilisers greatly increases root and nodule growth and thus contributes to crop health.

Application of lime or some other calcium formulation neutralises these acidic soils and increases nutrient availability. Calcium plays a crucial role in pod filling of peanut and several studies conducted elsewhere have shown that calcium is directly taken up by the pods. Hence, an adequate supply of calcium in the pod zone soil is necessary during the pod filling phase. Calcium deficiency results in a greater number of 'pops' (unfilled pods).

Inter-cultivation and weeding

Weeds, if left uncontrolled, can significantly reduce peanut yields and quality. Inter-row cultivation and weeding should be completed before pegging starts as any injury to the pegs or roots of the plants, increases infection by soil fungi such as *Sclerotium rolfsii* or *Aspergillus* spp. Most peanut gardens in the highlands receive one or two weedings when the crop is 3–4 weeks old.

Harvesting

Peanuts in the highlands are generally harvested 100–120 days after planting. Most farmers do a single harvest but some prefer multiple harvests over a period so as to sell peanuts as fresh pods-on-bunch. The conventional practice is to harvest the crop when the leaves turn yellow and start senescing. However, moderate to severe foliar diseases can cause leaf yellowing and sometimes may result in premature harvests. Harvesting is done manually by uprooting the crop or digging with spades. The area harvested depends on the availability of labour.

Harvesting is the most important phase of peanut production because the timing and operation affect the quantity and quality of yield. Peanut should be harvested at the right stage of maturity. Premature harvesting results in immature and poor-quality kernels, while delayed harvesting causes harvest losses (due to weakened pegs) and sprouting of overmature seeds in the field.

A great deal of work has been done on assessing peanut maturity and this needs to be extended to PNG peanut growers through appropriate training workshops.

Post-harvest drying

Peanuts are separated manually from the plant and sun-dried in the field for 4–5 days depending on the

Table 1. Influence of plant density and fertilisation on pod yield and total dry matter of two peanut varieties grown in the Markham Valley, Papua New Guinea during the 2004 season

Population* (plants ha^{-1})	Treatment	Pod yield (t ha^{-1}) Ex-Markham	Pod yield (t ha^{-1}) ICGV 95271	Harvest index Ex-Markham	Harvest index ICGV 95271
100 000	F1**	0.56	0.92	0.21	0.42
	F0	0.41	0.75	0.18	0.16
250 000	F0	0.71	1.05	0.38	0.39
	F1	0.63	0.86	0.34	0.35
	V × F	V × D	F × D	V × F × D	
SE	0.92	0.10	0.11	0.24	
CV%	12.6			32.5	

* 100,000 plants/ha (40 cm × 25 cm); 250,000 plants/ha (40 cm × 10 cm)

** F0 = zero fertiliser: F1= fertiliser (recommended rate) urea 20 kg N/ha top dressing; iron, zinc, copper sulfate, urea 2 kg/100 L/ha foliar spray

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

weather. Given high rainfall situations, peanut drying is one of the constraints for a successful peanut industry in the highlands, as there are no proper drying facilities to dry pods to safe moisture before storage, which is critical to maintain the quality and minimise aflatoxin contamination.

Shelling

Farmers usually shell peanut manually, which is labour intensive. There is scope to introduce manual or electrically operated shelling machines at the community level to cope with increased demand for seeds and shelled peanuts. Farmers need to be educated about mechanical peanut shelling and its usage.

Storage

Highland peanut farmers traditionally store peanuts as nut-in-shell. The shell acts as a natural protective covering for the relatively soft seeds against mechanical damage and insect infestation. Peanuts are stored either in plastic flour type sacks, in open earthen pots or in bamboo baskets. Kernels are often stored in sacks above the fireplace. Usually, peanut kernels are stored up to 2 months, while pods are stored for 6 months before planting.

Studies were conducted to examine the influence of storage conditions on the viability of peanuts at Aiyura. The different storage conditions used were ambient room temperature, cool room (4°C), and fireplace (25–28°C). The studies revealed germination and seed vigour index decreased by 50% by 6 months regardless of storage conditions used. The loss of viability in coolroom storage could be due to intermittent power cuts which could have resulted in a rise in relative humidity resulting in absorption of moisture by seeds. There was a trend for maintenance of higher seed viability up to 4 months in the case of seeds or pods stored in a fireplace compared to other storage conditions. While there was a trend for pods to have higher and longer seed viability compared to kernels, the differences were not statistically significant.

Conclusions

The highlands of PNG are characterised by high rainfall, high relative humidity and cooler temperatures. Under highly humid conditions, poor storage results in absorption of atmospheric moisture by the kernels and consequent microbial growth and rapid deterioration of quality. To minimise the effects of adverse conditions and maintain seed viability, it is recommended that peanut kernels be dried to >8% moisture and stored in sealed, moisture-proof packing material. However, this kind of material is not readily available for growers in PNG. Post-harvest cleaning and drying of pods to >8% moisture and storage in sacks in cool and dry conditions can maintain the viability of pods up to 6 months under Aiyura conditions.

At the commercial level, peanuts should be stored in air-tight containers/bags in an air-conditioned room at a relative humidity of 40% and a temperature of 15°C, to maintain seed viability for longer periods. There is need to develop cost-effective ways of storing peanuts under highlands conditions.

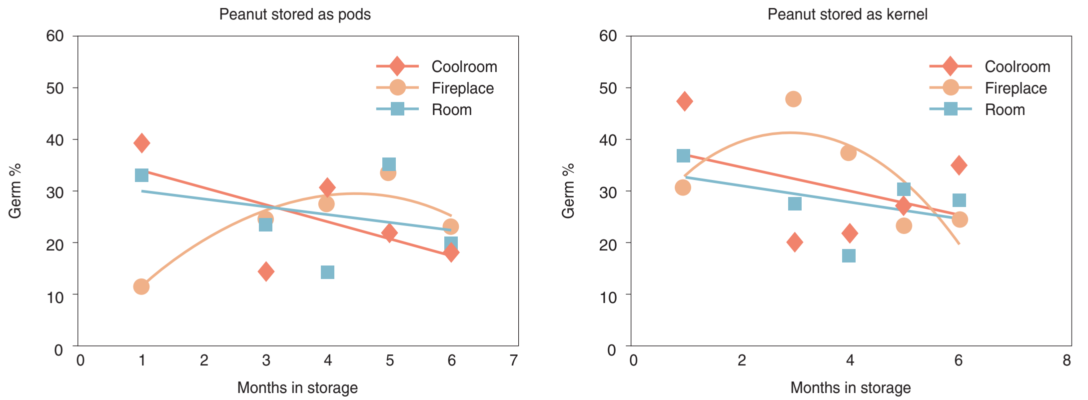

Figure 2. Effect of storage conditions on viability of (a) peanut pods and (b) kernels under Aiyura, Papua New Guinea conditions

References

Allen B.J., Bourke R.M. and Hide R.L. 1995 The sustainability of Papua New Guinea agricultural systems: the conceptual background. Global Environment Change 5, 297–312.

Dart P. 1977 Infection and development of leguminous nodules In 'A treatise on dinitrogen fixation', Section III Biology, eds Hardy R.W.F. and Silver W.S., pp. 367–472. JohnWiley and Sons: New York.

Hanson L.W., Bourke R.M., Allen B.J. and McCarthy T.J. 2001 Mapping land resource potential and agricultural pressure in Papua New Guinea. ACIAR Technical Report 50, 52 p.

Keig G. 1999 Rural population growth in Papua New Guinea 1980–1990. ACIAR project ASEM 1996/044 report 26 p.

McAlpine J.R., Freyne D.F. and Keig G. 2001 Land use and rural population change in rural PNG 1975–1995. In 'Food security in Papua New Guinea', eds Bourke R.M., Allen, M.G. and Salisbury J. ACIAR Proceedings 99.

Wemin J.M. and Geob T. 2004. Peanut production, utilisation and marketing in Papua New Guinea: a peanut farmer survey. Project report for ACIAR Project ASEM 2001/055. National Agricultural Research Institute, Aiyura, Papua New Guinea.

Wynne J.C., Elkan G.H., Schneeweis T.J., Islaib T.G., Preston N.M. and Meisner C.M. 1978 Increasing nitrogen fixation of the peanut. Proceedings of the American Peanut Research and Education Association 10(1):22–29.

Wynne J.C., Elkan G.H., Meisner C.M., Schneeweis T.J. and Ligon J.M. 1980 Greenhouse evaluations of strains of *Rhizobium* for peanuts. Agronomy Journal 72, 645–649.

Dr Ramakrishna, National Agricultural Research Institute, showing varietal differences in foliar disease resistance in a field trial at Aiyura in the Eastern Highlands Province of Papua New Guinea.

Evaluation of peanut (*Arachis hypogaea* L.) varieties in the lower Markham Valley of Papua New Guinea

Humphrey Saese, Geoff Fahey and John Bafui

Trukai Agribusiness Ltd, PO Box 2129, Lae, Morobe Province, Papua New Guinea; email: agronomist@trukai.com.pg

Abstract

As a part of the ACIAR funded project ASEM 2001/055, a total of 47 peanut varieties introduced from ICRISAT in India were evaluated at the Cleanwater site in Papua New Guinea, during the 2003, 2004 and 2005 seasons, with an aim of selecting the most promising genotypes suitable for cultivation in the lower Markham Valley region. The varieties were grouped into either short or medium-duration type based on their maturity, and evaluated in two separate trials in each season. In the 2003 and 2004 seasons, land was prepared into a flat bed, while during the 2005 season land was prepared into ridges separated by 45 cm furrows on either side.

In general, yields were higher in the 2005 season, with an average pod yield of 1.5 t/ha for medium-duration varieties in 2005 compared to <0.85 t/ha in 2003 and 2004. Similarly, the average yield of short-maturing varieties was 2.0 t/ha in 2005 compared to 0.94 t/ha in 2003. However, the data from the 2003 and 2004 trials were confounded with poor emergence, periodical local flooding and other biotic factors and hence were not considered for yield analysis. However, information on other parameters such as tolerance to foliar disease resistance and seed quality was assessed in all three seasons. Yield differences were not significant in the 2005 year trial, although the yields of ICGVs 95271, 96466, 95322, 96110, 93123, 93058 and 96108 were comparable to local check varieties. The kernel size of most of the short-duration varieties was smaller, with 100-kernel weight ranging from 42 to 53 g compared to >70 g in the case of medium-duration varieties. Some of these varieties were observed to be highly tolerant to foliar diseases, especially leaf spot and rust. The varietal trials will be repeated in the 2006 season.

Introduction

Peanut (*Arachis hypogaea* L.) was an important cash crop in the Markham Valley of Papua New Guinea (PNG) from the 1960s until the early 1980s. Up to 1500 hectares were sown annually giving an estimated production of 2250 tonnes (at a yield of 1.5 t/ha) of pods (Vance 1987). Peanut production declined rapidly from a commercial level in the 1970s to a subsistence level in the 1990s due to loss of export markets, reduced domestic demand and lack of R&D effort, including introduction and evaluation of new varieties.

Despite this setback, peanut flourished as an income earner for the majority of the local farmers in the Markham Valley and other parts of the country. It ranks as one of the top five income generating crops, with an estimated domestic production of over 12,600 tons p.a. (Wemin and Geob 2004).

It is hoped that introduction of new improved varieties and management practices to the smallholder sector will greatly enhance production and enable farmers to explore new market opportunities. During the 2001 season, 47 improved peanut varieties were introduced from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India and evaluated at the Cleanwater site in the lower Markham Valley. Although the varietal evaluation trials were conducted during the 2003, 2004 and 2005 seasons, the 2003 and 2004 season trials were either fully or partly damaged by local flooding or attack by wild pigs, resulting in significant loss of crop and thus making the data unsuitable for analysis. This paper describes the yield performance from the 2005 varietal trial and presents results on other crop parameters (such as foliar disease tolerance and seed size) from the 2003 and 2004 trials.

Material and methods

At the Cleanwater site, a crop rotation of rice–fallow–peanut or alternatively a rice–peanut–fallow system is generally followed. The fallow period is

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

6 months and weeds in the fallow basins are chemically controlled before the next crop is planted. The farm has access to water from a creek to provide supplementary irrigation if necessary. The site is, however, prone to prolonged periods of flooding during high rainfall periods.

In the lower Markham Valley the dry season lasts from May to October followed by the wet season from November to April. During the 2004–05 growing season the Cleanwater site received a total of 979 mm of rainfall (Figure 1) which was above the 9-year average of 687 mm (McAlphine et al. 1975). However, intermittent hot and dry spells are common during the growing season. The soil type is generally a clay loam texture with a pH of about 6.8 (Table 1).

These trial entries were grouped into either short-duration (SD) or medium-duration (MD) types based on prior knowledge about their maturity. According to the information available from ICRISAT, the SD varieties take about 90–120 days to maturity, while the MD types require 120–160 days to mature. As a result, 25 varieties were designated as MD and 28 as SD. The SD and MD varietal trials were conducted separately in each season.

Land was harrowed using an off-set, 2-row disc and ridged using a twin-ridger to form ridges at 80 cm intervals. The SD and MD trials were laid out as randomised complete block designs with three replications.

The varieties were planted in six rows, 5 m long, with a plant-to-plant spacing of 10 cm within a row and 80 cm between the ridges (which formed the rows in this trial), giving a total plot area of 20 m^2. A total of 300 seeds were planted per plot to achieve a target plant population of 150,000 per hectare. Pod yield data were collected from the inner two rows (net plot size of 12 m^2). The two trials were planted during 24–28 November 2004. Flooding occurred towards the end of March 2005, but the ridging operation greatly facilitated draining of excess water in the field. The trial was harvested towards the end of March.

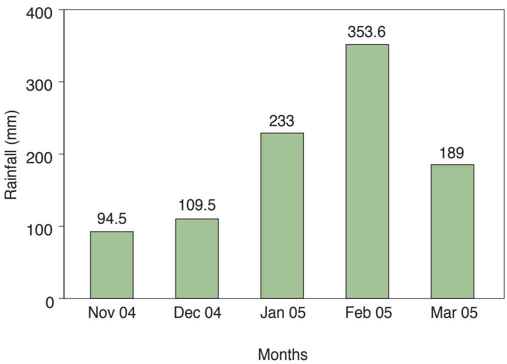

Figure 1. Monthly rainfall during the 2004–05 growing season at the Cleanwater site in the lower Markham Valley, Papua New Guinea

Table 1. Soil properties at the Cleanwater, Markham Valley, Papua New Guinea trial site

Soil parameter	Value
pH	6.8
Bulk density(g/cm3)	1.14
Soil texture	Clay loam
Nitrogen (%)	0.2
Organic carbon (%)	2.2
CEC (mEq/100 g soil)	49
Exchangeable K(mEq/100 g soil)	2.8
Phosphorus available (mg/kg)	24

(Source: Muneer, UNITECH, 2004, pers. comm.)

Data collection and analysis

The data on plant emergence were expressed as a percentage of the total seed sown. In both trials, days to 50% flowering were recorded at 30, 36 and 46 days after sowing (DAS), while plant dry matter (vegetative + pods) at flowering and at harvest was also determined. At flowering time, plants in a one metre row length were harvested from the edge rows in each replication and dried in an electric oven at 80°C for 48 h before recording dry weights. Pod yield data were collected from the inner two rows (net plot size of 12 m^2). Visual scoring of rust and late leaf spot infestation was made on a 1–10 point scale at 80 DAS. The data were analysed using the GENSTAT v4.32.

Results and discussion

Plant emergence began at 4 DAS for the SD varieties and around 10 DAS for the MD varieties. Emergence in the 2004–05 season ranged from <30% to >70% in both SD and MD varieties (Figures 2 and 3). Similar trends have been observed in previous trials. Poor emergence in some varieties is attributed to poor viability.

Plant emergence and flowering pattern

In the SD varieties, the mean germination was 56%, which was lower than that recorded in the previous trials. Varieties SD–7, SD–9, SD–13, SD–20, SD–22,

Table 2. Flowering pattern of medium-duration (MD) varieties during the 2004–05 season at the Clearwater site in the Markham Valley, Papua New Guinea

		% of plants flowering		
MD code	ICGV No	30 DAS	36 DAS	46 DAS
MD-1	92160	20	55	80
MD-2	93058	19	60	81
MD-3	93115	28	61	93
MD-4	93123	15	70	94
MD-5	93139	18	51	87
MD-6	93143	19	39	77
MD-7	94043	10	54	81
MD-8	94049	32	56	77
MD-9	94113	27	48	59
MD-10	94215	24	44	73
MD-11	95163	29	42	83
MD-12	95165	18	58	88
MD-13	95172	7	34	58
MD-14	95179	17	45	63
MD-15	96066	19	34	50
MD-16	96073	15	46	70
MD-17	96081	15	37	71
MD-18	96100	13	59	84
MD-19	96107	25	57	83
MD-20	96108	7	49	74
MD-21	96110	16	21	78
MD-22	96234	NA	NA	NA
MD-23	NG459	29	48	65
MD-24	K2	23	47	64
MD-25	K3	27	53	80
Mean		19	46.9	72.6
CV (%)		91.8	48.9	36.6
lsd		28.6	37.65	43.64

DAS = days after sowing.

Table 3. Flowering pattern of short-duration (SD) varieties during the 2004–05 season at the Clearwater site in the Markham Valley, Papua New Guinea

		% of plants flowering		
SD code	ICGV No	30 DAS	36 DAS	46 DAS
SD-01	92029	58	57	49
SD-02	94016	56	67	89
SD-03	94037	65	72	91
SD-04	94040	29	22	25
SD-05	94299	59	46	57
SD-06	94341	68	59	80
SD-07	94350	68	58	70
SD-08	94357	62	57	73
SD-09	94358	51	45	75
SD-10	94361	50	47	62
SD-11	95244	64	44	55
SD-12	95245	38	32	86
SD-13	95248	97	85	96
SD-14	95271	41	40	45
SD-15	95278	55	55	60
SD-16	95290	54	44	57
SD-17	95299	82	69	100
SD-18	95319	78	70	80
SD-19	95322	85	63	85
SD-20	95256	69	67	77
SD-21	95179	81	78	96
SD-22	96468	87	67	84
SD-23	96469	66	63	54
SD-24	96470	51	51	56
SD-25	96466	55	51	35
SD-26	Markham	32	32	37
SD-27	Keravat 4	28	26	49
SD-28	Aiyura	85	78	88
Mean		61.4	55.3	68.6
CV (%)		17.6	22.6	22.1
lsd		17.66	20.47	24.82

DAS = days after sowing.

SD–25, and SD–27 recorded emergence above 60% (see Tables 2 and 3 for varietal ID). The emergence was similar in the SD and MD trials. Varieties MD–2, MD–3, MD–19, and MD–24 gave mean germination above 60% (Figure 2) while emergence was poor for the rest of the cultivars. The MD varieties required seed treatment with Ethrel® growth regulator to break seed dormancy. About 50% of SD varieties achieved 60% emergence (Figure 3). However, the overall seed germination recorded in the 2005 trials was marginally lower than that recorded in 2003 and 2004.

First flowering was noted at 30 DAS in both the short and medium-duration trials. A total of 14 MD varieties reached >50% flowering in 36 DAS whilst the rest reached >50% flowering by 46 DAS (Table 2). More than 80% of SD varieties reached 50% flowering at 36 DAS whilst the remaining 20% reached 50% by 46 DAS. SD varieties reached maximum flowering much quicker than MD varieties. This trend is consistent with the previous trials.

Tolerance to rust (*Puccinia arachidis*) and late leaf spot (*Cercosporidium personatum*)

Leaf spot and rust diseases on peanuts were reported by Shaw (1984). These are common foliar diseases of peanut crops in the Markham Valley and elsewhere in PNG. Their incidence seemed to be closely associated with the onset of the rainy season. Infestations in this trial were observed around 80 days

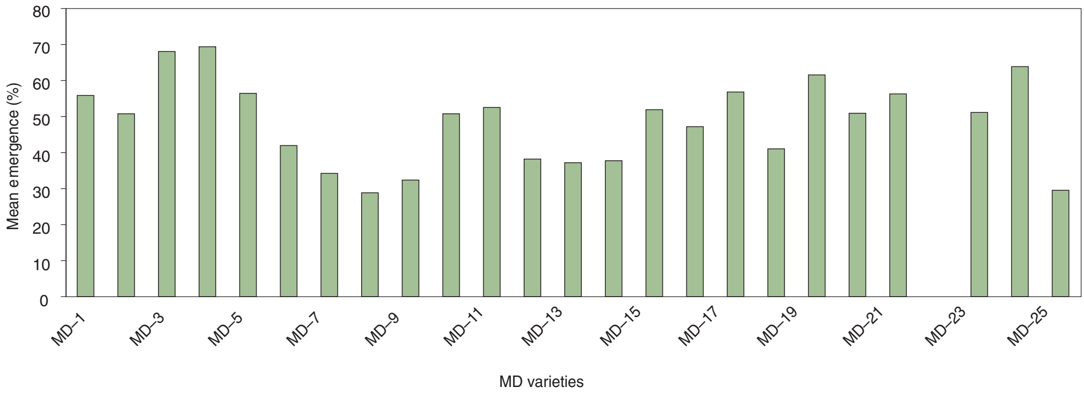

Figure 2. Percent emergence for medium-duration peanut varieties grown at Clearwater, Markham Valley, Papua New Guinea in the 2004–05 season

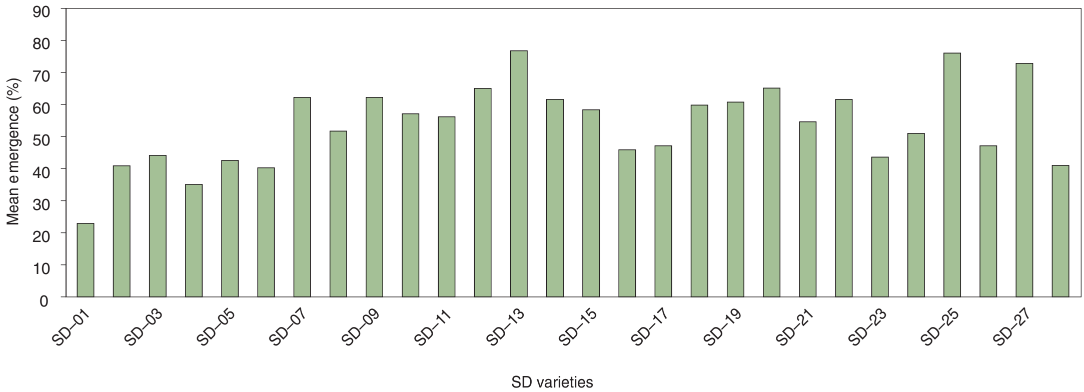

Figure 3. Mean plant emergence in short-duration peanut varieties grown at Clearwater, Markham Valley, Papua New Guinea in the 2004–05 season

after sowing which was at the peak of the rainy season. Leaf rust infestation was more severe, with trial mean scored at 5.16 compared to leaf spot with a score of 4. The varieties MD–8, MD–13, MD–15, MD–9, and MD–21 (Figure 4) were consistently tolerant to both leaf rust and late leaf spot, with tolerance above the trial mean (Figure 4). Most of the SD varieties appeared to be susceptible to leaf spot and rust with an overall trial mean at 6 compared to a mean score of 4 in the MD varieties. During the 2004–05 season, 10 SD varieties recorded foliar disease tolerance levels less than the mean rating of 6 (Figure 5). In both trials varieties that exhibited tolerance to the two diseases were mainly indeterminate in their growth and still maintained vegetative growth towards maturity. The indeterminate growth habit could account for the tolerance to these foliar diseases as they continuously rejuvenated and had more vigorous and healthy shoots and leaves.

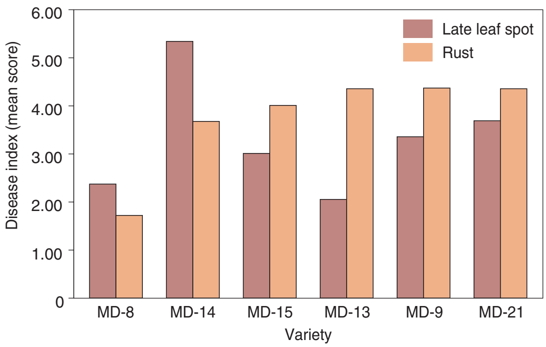

Figure 4. Varietal differences in foliar disease tolerance levels in medium-duration peanut varieties in a trial at Clearwater, Markham Valley, Papua New Guinea

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

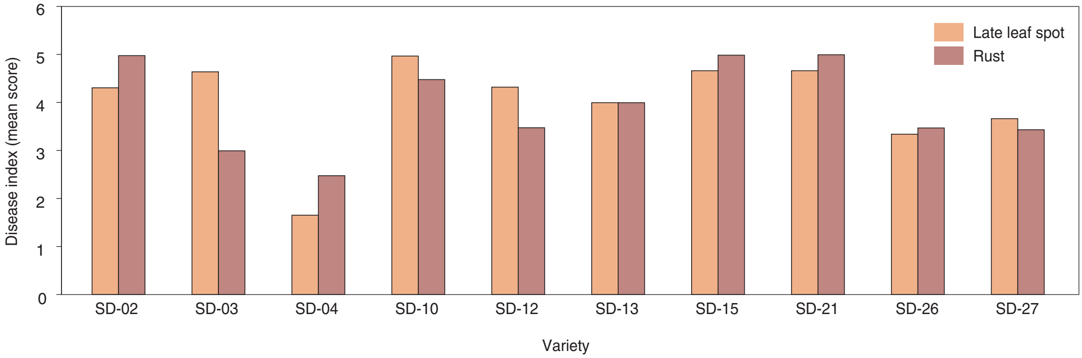

Figure 5. Varietal differences in foliar disease tolerance levels in short-duration peanut varieties in a trial at Clearwater, Markham Valley, Papua New Guinea

Yield performance

At the Cleanwater site, crop performance was better on ridges (2004–05) than on flat beds (2003 and 2004 seasons). The furrow and ridge type of land preparation could have contributed to the crop performance by reducing waterlogging in the podding zone. It was clear that appropriate land preparation is an important factor for improving productivity of peanut. Planting the crop on ridges could have prevented waterlogging in the pod zone and improved aeration to pods and roots. The yields from the 2004–05 trials averaged around 2.2 and 1.4 t ha^{-1} for SD and MD varieties respectively. A total of 12 SD and 8 MD varieties have been selected for further evaluation based on the above average performance of yield, 100 seed mass, shelling per cent and harvest indices, as presented in Tables 4 and 5.

Joint inspection of a peanut trial in the Markham Valley, Papua New Guinea by NARI and Trukai officers. From left: Timothy Geob and Ramakrishna (NARI); John Bafui and Humphrey Saese (Trukai).

Table 4. Promising short-duration peanut variety selections based on yield parameters

Genotype/ ICGV No.	TDM at harvest (t/ha)	Pod yield (t/ha)	Shelling %	100 seed wt (g)	Harvest index
Ex-Kerevat-4	4	3.20	60	42	N/A
95244	4	2.92	65	39	0.67
95245	4	2.78	66	35	0.65
95248	4	2.78	66	41	N/A
95271	5	2.64	65	43	0.54
95299	3	2.50	64	41	N/A
95319	5	2.50	66	41	0.68
95322	4	2.50	67	30	0.65
95256	5	2.50	66	34	0.6
96468	4	2.36	64	62	N/A
96466	5	2.36	68	45	0.7
94016	3	2.22	69	56	0.62
94037	3	2.22	34	41	0.69
94299	4	2.22	64	40	0.64
94341	4	2.08	68	36	0.46
94350	4	2.08	65	39	0.46
94357	3	2.08	68	34	N/A
94358	3	2.08	66	38	0.69
94361	4	2.08	66	39	0.56
95278	4	2.08	65	43	0.54
95290	4	1.94	65	44	0.53
95179	3	1.94	66	33	0.65
96469	4	1.94	73	46	N/A
96470	5	1.81	62	44	0.45
Ex-Markham	4	1.80	66	39	0.49
Ex-kerevat-2	4	1.67	64	48	0.55
92029	4	1.25	65	46	0.34
94040	3	1.11	62	46	0.41
Grand mean	4	2.20	66	42	0.63
CV%	23	26.39	5	11	32
LSD	2	0.95	5	8	0.33

TMD – total dry matter; N/A – data not available.

Table 5. Promising medium-duration peanut variety selections based on yield parameters

Genotype/ ICGV No	TDM (t/ha)	Pod yield (t/ha)	Shelling %	100 seed wt (g)	Harvest index
Ex-Markham	3	2.20	70	42	0.68
Ex-Kerevat3	3	2.15	55	49	0.52
96110	5	2.08	66	98	0.51
Ex-Kerevat2	5	2.06	67	44	0.53
93139	4	1.96	66	55	0.53
93123	3	1.88	64	54	0.59
93058	4	1.71	62	91	0.48
93115	4	1.53	66	50	0.41
96108	4	1.49	55	90	0.39
92160	5	1.41	68	97	0.33
94113	4	1.4	62	45	0.44
96073	4	1.38	65	90	0.37
96081	4	1.38	69	84	0.31
96107	4	1.22	67	51	0.28
95165	4	1.17	66	92	0.32
93143	6	1.16	64	55	0.21
95163	3	1.16	68	92	0.33
94049	3	1.04	57	81	0.28
94043	4	0.95	57	80	0.31
94215	4	0.94	58	81	0.34
96100	6	0.75	69	75	0.26
Grand Mean	4	1.44	64	71	0.4
CV %	27	37	13	12	44
lsd (P>0.05)	2	1	14	15	0.3

TDM – total dry matter

Conclusions

The overall yield performance of all genotypes was better on ridges compared to the flatbed system. In the SD varieties, the grand mean yield of 2.2 t/ha represents a >42% increase in overall yields compared to 0.93 t/ha in 2003 (2003 trial report). In the MD variety trial the mean yield was 1.44 t/ha which represents a 24% increase in yield compared to the average yield of 0.34 t/ha in 2003.

The results from the 2005 season indicated that none of the new varieties yielded significantly higher than the local check Ex-Markham. However, limited data available from the 2003 and 2004 seasons showed that some of the new varieties outyielded the local check variety. It is planned to repeat the varietal trial at another site to confirm the yield performance before drawing conclusions on varietal selection. The trials demonstrated that the new varieties had other advantages such as larger kernel size and high levels of disease tolerance.

Acknowledgment

The authors wish to thank the Australia Centre for International Agricultural Research for funding under the ACIAR project ASEM2001/055 to conduct these studies. Many thanks also to Dr R.C.N. Rachaputi and Dr Graeme Wright for reviewing the manuscript. The support from the management and staff at Trukai Farms Ltd and the National Agricultural Research Institute is appreciated.

References

McAlpine J.R., Keig G. and Short K. 1975. Climatic tables of Papua New Guinea. CSIRO Land Use Technical Paper No. 47, Melbourne.

Shaw, D.E. 1984. Microorganisms in Papua New Guinea. Research Bulletin No 33, Department of Primary Industry, Port Moresby.

Vance P.N. 1987. Agronomic studies of peanut in Papua New Guinea. Research Bulletin No. 42, p. 3, Department of Primary Industry, Port Moresby.

Wemin J.M. and Geob T. 2004. Peanut production, utilisation and marketing in Papua New Guinea: a peanut farmer survey. Project report for ACIAR Project ASEM 2001/055. National Agricultural Research Institute, Aiyura, Papua New Guinea, p 15.

Effects of storage conditions on the seed viability of peanut in highland and lowland regions of Papua New Guinea

Humphrey Saese[1], Geoff Fahey[1], Isidore Sau[1], John Bafui[1], A. Ramakrishna[2], Yanding Tomda[2] and Timothy Geob[2]

[1]*Trukai Agribusiness Ltd, PO Box 2129 Lae, Morobe Province, Papua New Guinea; email: agronomist@trukai.com.pg*

[2]*National Agricultural Research Institute, PO Box 210, Aiyura, Eastern Highlands Province, Papua New Guinea*

Abstract

Storing peanut for up to 3 months over the fireplace before planting is a common practice followed by peanut growers in Papua New Guinea. According to a farmer survey, about 60% of peanut growers keep their own seed for planting the next crop. As peanut is generally cultivated in the wet season, farmers keep their seed or source seeds from dry-season-grown crops which are normally of inferior quality. The seed material is stored as pods or kernels under varied conditions. To study the effects of storage conditions on seed viability, trials were conducted in the lowlands (Erap) and highlands (Aiyura) of Papua New Guinea.

Results suggest that the rate of decline in seed viability is much slower at Aiyura (0.15% per week) compared to 2% per week at the Erap site. Seed viability declined sharply under fireplace storage conditions, while seeds stored in an air-conditioned container and ambient room conditions maintained viability above 80% for up to 3 months. Significant ($P<0.05$) differences were observed between pods and kernels with nut-in-shell having an average germination rate of 66% compared to 46% for kernels over a 6-month period. The best storage practice at both sites was to keep seeds either in a refrigerator or a cool-room with low relative humidity.

Introduction

In Papua New Guinea, peanuts and other grain crops are generally stored in plastic fertiliser or flour bags at ambient room temperatures (25–30°C) or above the fireplace for later planting. A recent survey conducted by the ASEM 2001/055 project revealed that 60% of growers purchased seed material from road-side markets, while 40% of growers stored seed in bags in their homes or above the fireplace. This study examined the effect of various traditional storage practices on seed viability.

Initial trials at Trukai Farms, Erap in the lower Markham Valley highlighted significant differences in seed viability between different storage practices. The storage conditions compared were: air-conditioned container, ambient room condition and fireplace in a house. These trials were conducted at Erap (lowlands) and Aiyura (highlands). The two sites are distinctly different in their climates because of their elevation and rainfall, with Erap being warmer, drier and humid, while Aiyura is cooler, wet and humid. The paper presents the results on viability of seeds stored under various conditions in lowland (Erap) and highland (Aiyura) environments.

Material and methods

The four storage treatments were refrigerator, air-conditioned container, ambient condition and above a fireplace (in a house). About 1800 kernels or pods were kept in three separate bags (three replications) under each condition at the two sites. Seed germination tests were conducted at monthly intervals over a 5 or 6-month period to determine seed viability.

A sub-sample of 100 kernels or pods was drawn from each storage treatment and germination tested. The data were analysed using 'Statistix version 8'.

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

Table 1. Germination percentage of peanut seed under different storage conditions at Erap (lowland region), Papua New Guinea over 5 months

Storage	Storage period (months)				
	1	2	3	4	5
Refrigerator	68c	93a	78a	69a	65a
Ambient/room	98a	25b	57b	35c	29b
Fireplace	84b	29b	38c	15d	14c
Grand mean	84	57	59	43	41
CV%	10	28	20	29	28
lsd	10	9	14	15	14

Nb: Values followed by same letters in each column are not significantly different ($P<0.05$).

The average rate of change in viability was determined by dividing the difference between the initial and the final germination over the time in weeks.

Results and discussion

Erap in the lower Markham Valley and Aiyura in the highlands represent contrasting environments and thus may have varying effects on seed viability. The study compares the differences in viability of kernels and pods stored under different storage practices in highland and lowland conditions.

At Erap, germination ranged from 68 to 98% at the start of the experiment, but viability declined at different rates depending on the storage conditions (Table 1). Local storage practices, such as storing seeds above the fireplace or under ambient conditions, resulted in a rapid decline in seed viability. The decline in seed viability was much faster (3.8%/week) for the fireplace treatment compared to 3.4% for storage under ambient conditions. The best method of storing seeds in the lowlands was in a refrigerator which maintained seed viability throughout the 5-month period (Table 1).

The decline in viability was much slower (1.65%/week) under refrigerated conditions. Interestingly, even refrigerated storage recorded viability falling below 80% from the third month.

Under lowland conditions pods maintained viability significantly ($P<0.05$) better than kernels (Table 2). The seed germination rate of pods declined in the third month at the rate of 1.5% per week while germinability of kernels declined at the rate of 2.2% per week from the second month to 25% per week by the fifth month (Figure 1).

The following three storage treatments were used at Aiyura: air conditioned, ambient condition and fireplace. The effects of the treatments were different in Aiyura compared to Erap. Although samples were drawn at monthly intervals, the results of the second month sampling had to be discarded due to poor quality data. The results showed that the seed viability in the coolroom was 78% at the start of the experiment and declined to 50% by the fourth month (Table 3). It was possible that frequent power cuts at the research station would have resulted in rises in

Table 2. Effect of storage period on germination percentage of pods and kernels stored under ambient conditions at Erap (lowlands)

Seed form	Storage period (months)				
	1	2	3	4	5
Pods	90a	62a	72a	51a	57a
Kernel	77b	51a	46b	35b	24b
Grand mean	83	57	59	43	41
CV%	10	28	20	29	28
lsd	7	13	10	11	10

Nb: Values followed by same letters in each column are not significantly different ($P<0.05$).

Table 3. Germination percentage under different storage conditions for the Highlands region (Aiyura)

Storage	Storage period (months)				
	1	2	3	4	5
Cool-room	78a	36b	52a	47a	51a
Ambient	67ab	53ab	34a	67a	43a
Fireplace	44b	78a	58a	66a	42a
Grand mean	63	56	48	60	45
CV%	27	36	44	44	21
lsd	28	33	34	42	15

Nb: Values followed by same letters in each column are not significantly different ($P<0.05$).

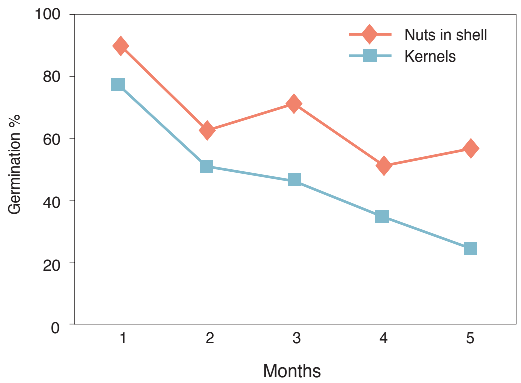

Figure 1. Viability of peanut seeds stored as pods and kernels at Erap (lowlands), Papua New Guinea

temperature and humidity in the coolroom which might have confounded the results. There were no significant differences between ambient and fireplace storage treatments. At Aiyura the difference between kernels and pods were not significant (Figure 2) although there was a trend for reduced seed viability in kernels compared to pods.

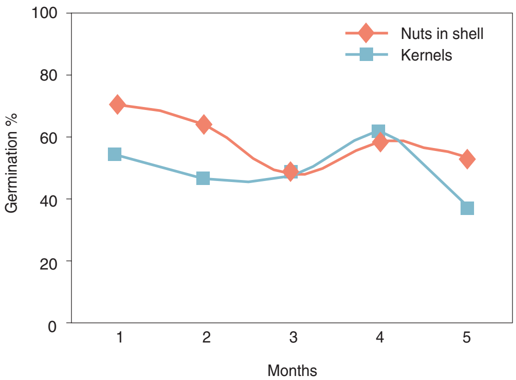

Figure 2. Seed viability of peanut pods and kernels stored under ambient conditions at Aiuyra (highlands), Papua New Guinea

Conclusions

The storage trials demonstrated that at Erap (lowlands), seed material stored in the form of pods maintained higher viability than kernels. The results have also demonstrated that the conventional practice of storing seed over the fireplace results in rapid decline in viability under lowland conditions. Although air-conditioned storage maintained viability for longer periods of time this facility may not be easily available to smallholders, hence there is need to develop cost-effective storage methods to maintain seed viability under lowland conditions.

At Aiyura (highlands), the data showed that the rate of decline in seed viability was much slower than in the lowlands. However, the seed stock recorded poor germination at the start of the experiment, indicating poor quality of seed source. There were marginal differences between pods and kernels, with kernels having slightly (but consistently) lower seed viability.

Based on these trials it can be concluded that, in the highlands, seed material can be stored either as pods or kernels under cool and dry conditions. However, pods maintained marginally higher seed viability than kernels. On a commercial scale, air-conditioned storage should be used in both lowland and highland situations to store seed 6 months or longer periods.

Staff of Trukai Farms, Erap, Papua New Guinea. From left: Humphrey Saese, Julie Kolopen and John Bafui.

Comparison of seed dressing treatments of peanut (*Arachis hypogaea* L.) at Cleanwater in the lower Markham Valley, Papua New Guinea

Humphrey Saese and Geoff Fahey

Trukai Agribusiness Ltd, PO Box 2129, Lae, Morobe Province, Papua New Guinea; email: agronomist@trukai.com.pg

Abstract

While seed dressing with chemicals is a routine practice in commercial production, it is not a common practice in Papua New Guinea (PNG). Rather, soaking of seed in water overnight prior to planting is commonly practised with a belief that it improves seed germination. However, there is no information about the effectiveness of the local practice. There is a need to explore cost-effective seed-dressing techniques that are effective in controlling seed and soilborne diseases.

The paper describes results from various seed dressing trials conducted during the 2003–04 season at Trukai Farm's Cleanwater site. The study showed that appropriate seed-dressing treatments can reduce seedling mortality due to soilborne pests and diseases. Losses up to 50% of the total seed sown were observed in untreated plots. This trial highlighted that either captan fungicide alon,e or as a mix with carbaryl insecticide at the rate of 3 g per 10 kg, was most effective in reducing seedling mortality.

Introduction

Seed dressing is a standard practice in commercial peanut production in developed countries. The aim of seed dressing with appropriate pesticides is to reduce incidence of seedling diseases (Crosthwaite 1994) caused by either seed or soilborne micro-organisms. Seed treatment, in general, improved the germination of both hand and machine shelled seeds by 30 to 50%. In Australia, it is recommended to treat peanuts seeds with a captan/quintozene or Euparen/quintozene mix (Crosthwaite, 1994). A similar practice is adopted at Trukai Farms in the lower Markham Valley in Papua New Guinea (PNG) where seeds are treated with captan fungicide at the rate of 3 g per 10 kg of seed to improve crop establishment.

While seed dressing with chemicals is a routine practice in commercial production, it is not a common practice in PNG. However, soaking of seed in water overnight prior to planting is commonly practised with a belief that it improves seed germination. However, there is no information about the effectiveness of the local practice. With the anticipated increase in commercial production, there is a need to explore cost effective seed dressing techniques which are easily adopted by growers. It is believed that farmers can achieve higher yields by treating seeds with recommended chemicals, thus reducing seedling mortality due to seed and soilborne diseases. The paper describes results from seed dressing trials conducted during the 2003–04 season at Trukai Farm's Cleanwater site.

Material and methods

A local peanut variety NG7970 (previously called NG459), which is a White Spanish variety, was used for the study. This variety was initially introduced to produce nuts for roasting (Kado, pers. comm.) and is now grown by most farmers in the Markham Valley. The variety is also known as *pukpuk skin* peanut, to distinguish it from other Spanish varieties grown in PNG. A separate seed germination test revealed a 71% germination rate before the seed lot was used in the trial (Table 1).

A randomised block design was used to evaluate five seed dressing treatments which were replicated four times (Table 2). Seeds were treated a day before planting. For all the captan and combined captan + carbaryl treatments, the seeds were dusted with the prescribed amount of chemical (Table 2), while seeds for the neem product treatment were soaked in the neem oil

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

Table 1. Plant emergence at 7 days after sowing

Chemical	Rate	Germination (%)	Plant population
Captan/carbaryl	1:1 mix/kg*	91a	161905
Carbaryl–insecticide	0.3 g/kg	81ab	158333
Captan–fungicide	0.3 g/kg	80ab	154762
Neem product	N/A	70b	119048
Control	0	45c	71429

* 1.5 kg each of captan and carbaryl mix.
** Treatments with the same letter are not significantly different (P<0.05).

Table 2. Seed dressing treatments used in the trial

Chemical	Rate	Mode of treatment
Captan-fungicide	3 g/kg	Dusted
Carbaryl-insecticide	3 g/kg	Dusted
Carbaryl+captan	1.5 g/kg	Dusted
Neem product	10 mL/L	Soaked
Control	Nil	Water soaked

(10 mL/L water) for 10 minutes, removed and left overnight. The trial was planted on 8 August 2003.

Planting was done manually by dibbling seeds at 10 cm interval to a depth of 5 cm. A single seed was placed in each hole and covered with soil. At the time of planting the soil had adequate moisture supplied from a flood irrigation system.

Crop emergence was recorded at one, two and four weeks after planting. Most treatments had established between the first and second week after sowing. A visual score rating of 1–5 was used to assess crop vigour, with a score of 1 representing a vigorous crop and 5 being poor vigour. Plant count and effective row lengths were measured to determine the final plant population at 60 days after start of each treatment.

Results and discussion

There was a significant (P<0.05) difference in seed germination due to seed dressing treatments with the germination rates ranging from 45% in the control to 91% in the captan + carbaryl treatment (Table 1). The captan + carbaryl combination treatment (50:50) at the rate of 1.5 g/kg seed resulted in the best emergence (91%) (Table 1). The carbaryl treatment deterred red ants from attacking the delicate seeds. Neem product (oil) treatment gave similar germination results, but handling of the product is not safe and the odour is unpleasant to the operator. The control treatment (untreated) produced a very low field emergence of 45% although the pre-planting germination showed 71% germination in control seeds. The results clearly demonstrate the impact of these seed treatments in preventing seedling losses in the field. The huge differences between germination level *in situ* and on tissue paper confirms that soilborne organisms must account for a major difference in the germination. Low field emergence in the control treatment was largely due to insects, which tunneled into the delicate endosperm rending the seeds vulnerable to secondary infection by other saprophytic micro-organisms.

While the practice at Cleanwater involved only the captan treatment, the inclusion of insecticides will have the possible benefit of deterring insects such as ants (common at Cleanwater site) from damaging the delicate endosperm and subsequently opening the tissues for further infection by soilborne micro-organisms.

Plant vigour scoring followed a similar pattern to plant emergence with the captan, carbaryl and combined treatments giving more vigorous plants compared to the neem oil and control treatments (Figure 1) which scored below the trial average of 3. It was interesting to note that whilst seeds treated with neem oil had comparable plant emergence to those treated with captan, carbaryl and the combined treatment, the low plant vigour observed may suggest a retarding effect of the oil product on the growth of seedlings.

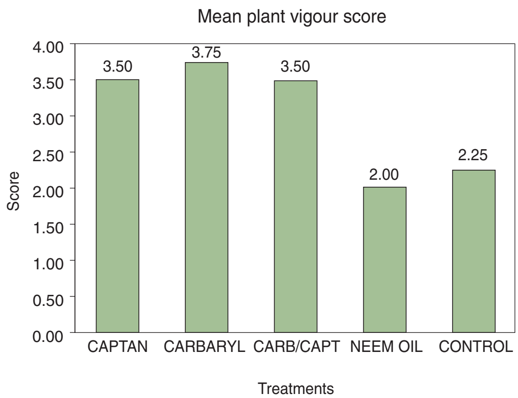

Figure 1. Effect of peanut seed dressing treatments on crop vigour rated at 60 days after sowing

Cost of seed dressing

Most farmers in PNG are not aware of the economic benefits of applying seed dressings on their peanut crops. In this trial the cost of chemicals ranged from K21.00 to K41.00 per hectare (Table 3). In the Markham Valley this would equate to K7.10 to treat

Table 3. Cost of peanut seed dressing treatments

Chemical	Market price (K/pkt)	Price/g	Rate of treatment	Cost per kg of seeds (K/kg)	Seed rate/ha (kg)	Cost/ha (K)**
Carbaryl	26.75/200 g	0.13	3 g/kg	0.39	54	21
Captan	37.47/150 g	0.25	3 g/kg	0.75	54	41
Captan/carbaryl	N/A	0.18	1:1 mix/kg	0.57	54	31
Neem oil	N/A	N/A	10 mL/L	N/A	54	N/A
Control	0	0	0	0	0	0

* Estimated based on 54 kg/ha Markham variety (Spanish White-NG7970).

** Excludes cost of labour for treating seeds.

seeds with a carbaryl/captan mix for an average area of 0.23 hectares, while at the Cleanwater site, the seed dressing cost would average K31 per hectare. The results also showed that the final plant population ranged from 154,000 to 158,000 plants per hectare in the captan + carbaryl treatment compared to 71,000 plants per hectare in the untreated control.

Conclusion

The results from this study clearly showed that seed dressing will reduce seedling mortality due to soil-borne pests and diseases. Losses up to 50% of the total seed sown can be expected if seeds are not treated with appropriate seed dressing chemicals. This trial highlighted that either captan fungicide alone or as a mix with carbaryl insecticide at the rate of 3 g per 10 kg of seed improves field germination of seeds. The trial demonstrated that the seed dressing is a cost effective practice with costs being minimal (K31 per ha) to achieve optimum crop establishment. Field germination of seeds treated with neem oil was comparable to the other treatments, but total dry matter production was reduced, suggesting it may have a retarding effect on seedling growth.

References

Crosthwaite I. 1994. Peanut growing in Australia. Queensland Department of Primary Industries Information Series No: Q194019, Agdex 141/10.

Trukai Farms and DPI&F project team members with a peanut grower's group at a Genaf village in the lower Markham Valley, Papua New Guinea

Evaluation of peanut varieties suitable for the upper Markham Valley, Papua New Guinea

Lastus S. Kuniata

Ramu Sugar Ltd, PO Box 2183, Lae 411, Morobe Province, Papua New Guinea; email: lkuniata@ramusugar.com.pg

Abstract

Peanut is a potential crop for smallholders, which has been grown in Papua New Guinea (PNG) for more than 40 years. Yields are usually low due to poor crop husbandry and low inputs. Most of the varieties grown are also old. In the last 3 years a number of new varieties were introduced from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in India for evaluation under PNG conditions. The paper presents results from field trials conducted at the Ramu Sugar site in the upper Markham Valley. Up to nine varieties have been selected and are being multiplied up for commercial production and also for distribution to smallholder farmers.

Introduction

Peanuts have been grown in the Markham Valley of Papua New Guinea for over 40 years. The local farmers often grow 2–3 crops per year under rainfed conditions. Peanut plots are usually up to 0.5 ha with average yields ranging from >0.9 to 2.0 t/ha.The most popular variety grown in Markham is called 'Yarang' or puk-puk meaning crocodile skin. The variety takes up to a minimum of 15–16 weeks from planting to harvest. Peanut is an important cash crop for smallholders with a selling price of K30–50 for a 25–30 kg bag in the local markets.

During peak commercial production from the late 1950s to the 1960s, up to 1800 tonnes of kernel were exported to Australia with a total value of K600,000 (A$1 = K3). A factory was also established at Taraka (Lae) and operated by Sanitarium to produce peanut butter, most of which was consumed locally. After 1967 commercial peanut production declined to the extent that there were no significant exports by 1974–75. In the late 1980s, about 200 tonnes of peanuts were produced on a semi-commercial basis using the varieties Virginia Bunch and Red and White Spanish.

The main problems identified then, which contributed to the decline in peanut production were:

- quality of seeds
- weed competition, especially *Rottboellia cochinchninesis*
- disease, mainly leaf spots, rust and white mould
- intensive cultivation without fertiliser or crop rotation
- lack of appropriate agronomy
- machinery limitations
- land tenure problems
- lack of reliable markets.

Climate

There have been no reliable rainfall records kept for various localities along the Markham Valley. However, data obtained showed that the annual rainfall ranged from 1450 mm at Nadzab to about 1950 mm at Ramu Sugar (Table 1). Rainfall tends to increase up the valley apart from Lae.

The Ramu Sugar estate is located in the Ramu Valley at about 400 m asl. Annual rainfall is about 2000 mm and most rainfall occurs between late September to early June as a consequence of the north-west monsoon. The June to September period is usually the driest with an average of 95 mm per month. March is the wettest month with a mean rainfall of about 280 mm (Figure 1). Evaporation (class A

Table 1. Average rainfall observed in the Markham Valley, Papua New Guinea

Station	Annual rainfall (mm)
Lae	4500
Nadzab	1450
Leron	1500
Gusap	1840
Ramu Sugar	1950
Dumpu	1770

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

pan) exceeds total rainfall from May to November. Mean annual temperature on the estate is 26.8°C with only minor fluctuations throughout the year.

Soils

The soils on Ramu Sugar estate are derived from alluvial deposits from the Ramu River and its tributaries. Soil chemical and physical properties have been discussed in detail by Hartemink (1998). Common soil types are Fluvisols, which are characterised by having clear stratification; Vertisols, which have heavy clays that swell and shrink during wet and dry seasons; and Phaeozems, which have thick, black topsoils. Gleysols, which have stagnating water during the rainy season, occur on some parts of the estate (Charters 1981). Similarly, small areas to the east have Allofane soils. Soil pH is between 5.8 and 6.7 (Table 2), indicating that there is no apparent danger from exchangeable aluminum or excess $CaCO_3$. Soil salinity is not a problem in the topsoils.

The lighter alluvial soils are known locally as shallow and deep loams. These soils appear to be quite friable and reasonably well-drained (which is important for peanuts). Sampling carried out by Ramu Sugar indicated that the soils are reasonably fertile) (Ramu Sugar Ltd, internal report), although some of the light soils were low in phosphorus (Table 2). Peanuts may not have a high nutrition requirement, but they require adequate levels of all macro and micro nutrients.

This paper reports the results from 3 trials conducted during 2002–2004. A total of 31 varieties from ICRISAT, India were received from Trukai Industries in 2002 intended for evaluation under Ramu Sugar/upper Markham conditions. Potential varieties would be selected for distribution to smallholder farmers and also for commercial production in future.

Table 2. Typical soil nutrient levels for soils in the Ramu Sugar area, Markham Valley, Papua New Guinea. Similar levels were also observed in the Leron area.

	Units	Sample ranges	Comments
pH		5.8–6.7	OK
Nitrogen	(%) total N	0.14–0.29	OK
Phosphorus	(mg/kg) Olsen P	10.6–61.2	Low – mod. high
Potassium	(% me)	0.53–1.94	Good
Sulfur		Not available	
Calcium	(% me)	17.7–29.7	High
Magnesium	(% me)	3.58–16.9	High
CEC	(% me)	18.9–42.4	OK

Material and methods

All the trials were conducted at Ramu Sugar's block number CN108 (inside the golf course area). The dominant soil type in the trial plot was deep loam with moderate soil nutrients (Table 3).

Table 3. Summary of soil analysis for the trial site in the Markham Valley

pH	Extractable bases Ca	Mg	K	Na
6.3	22.7	7.55	1.73	0.17

CEC (me%)	BS (%)	Olsen P	Organic C (%)	Total N (%)	C/N ratio	Mg:K ratio
28.8	112	25.7	2.96	0.16	19	4

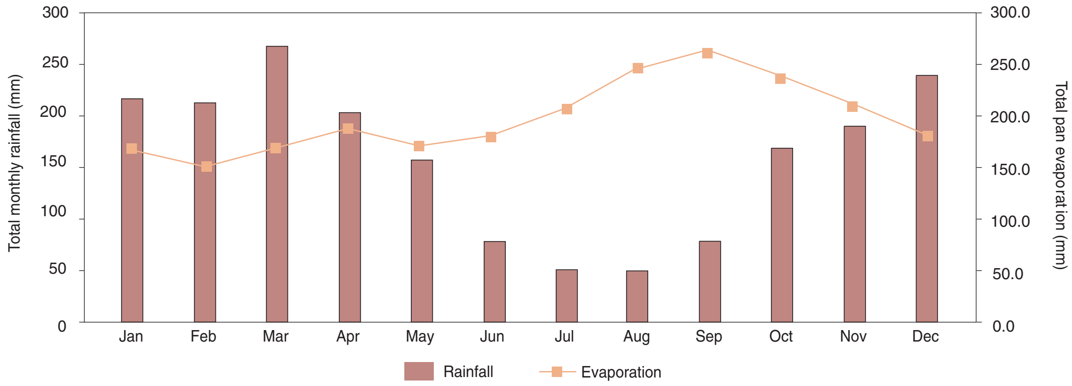

Figure 1. The long-term (1980–2004) monthly mean rainfall and class A pan evaporation at Ramu Sugar estate, Markham Valley, Papua New Guinea

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

Table 4. Details of peanut varieties used in trial 1

VarCode	Variety ID	Comments	VarCode	Variety ID	Comments
1	ICGV 94299	Test	18	ICGV 96469	Test
2	ICGV 94341	Test	19	ICGV 96470	Test
3	ICGV 94350	Test	20	ICGV 95256	Test
4	ICGV 94357	Test	21	ICGV 92029	Test
5	ICGV 94358	Test	22	ICGV 93115	Test
6	ICGV 95244	Test	23	ICGV 93123	Test
7	ICGV 95245	Test	24	ICGV 93139	Test
8	ICGV 95248	Test	25	ICGV 93143	Test
9	ICGV 95271	Test	26	ICGV 94016	Test
10	ICGV 95278	Test	27	ICGV 94037	Test
11	ICGV 95290	Test	28	ICGV 94093	Test
12	ICGV 95299	Test	29	ICGV 94094	Test
13	ICGV 95319	Test	30	ICGV 94113	Test
14	ICGV 95322	Test	31	ICGV 94040	Test
15	ICGV 94361	Test	32	Yarang	Local check variety (crocodile skin)
16	ICGV 96466	Test	33	Kesowai	Local check variety
17	ICGV 96468	Test			

Trial 1

The trial was planted on 16 May 2002 with 31 test and 2 local check varieties (Table 4). In trial 1, the varieties were not separated into groups of short-duration and medium-duration. A completely randomised block design with three replicates was used. The plot sizes used were 2 m × 4.5 m with plant spacing of 40 cm between rows and 20 cm between plants. Maturity testing was carried out from the fourth month after planting and those varieties with more than 80% mature pods were harvested. First harvest was made on 17 September and the rest were harvested on 1 October 2002. In each plot, the yield data were collected from the inner two rows. Yields were recorded after sun-drying the pods for at least 5 days. In addition to pod yield, 100-seed weight and shelling percentage were recorded for all the varieties.

Total rainfall received during the trial period was 277 mm. The distribution was inadequate (only 127 mm received from June to September) so supplementary irrigation was carried out with a water tanker.

All the data were analysed using the statistical software Statistix 8.

Trial 2

Trial 2, which was a repeat of trial 1, was planted on 28 November 2002. The layout and plot sizes were similar to trial 1. The varieties were harvested on 8 March and 2 April 2003 after assessing the maturity (by blackening of inner shell wall). Since 100-seed weight and shelling percentage were already done in trial 1, these were not repeated. Only pod yields and pest damage were estimated.

Total rainfall received during the trial period was 1006 mm with a normal distribution throughout.

Trial 3

A total of 20 varieties were evaluated in trial 3 (Table 5). The trial design was a randomised complete block with four replicates. Plot sizes were 1.8 m × 4 m with plant spacing of 60 cm between rows and 20 cm between plants. This trial was planted on 6 September 2003 and harvested on 5–7 February 2004. Before planting, mill mud from the sugar mill was applied to the whole trial block at the rate of 60 tonnes ha^{-1}. Three weeks after germination, the crop was top dressed with di-ammonium phosphate at the rate of 40 kg ha^{-1}.

Good rainfall (62 mm) received prior to planting resulted in good crop establishment. A total rainfall of 1218 mm was received, distributed evenly during the trial period.

At harvest, yields were estimated by harvesting all the plants in each plot (no guard rows). Earwig damage was assessed on two plants randomly selected from each plot. The plants were dug out using a spade (20 cm × 20 cm × 20 cm) and the soil spread out on a white bag. The soil was carefully searched for earwigs and click beetles. The damaged pods were counted from the uprooted plants.

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

Table 5. Details of peanut varieties used in trial 3

Varcode	Variety ID	Comments
1	ICGV 96160	New
2	ICGV 93058	New
3	ICGV 94215	New
4	ICGV 94299	Selected from 2 trials
5	ICGV 94341	Selected from 2 trials
6	ICGV 95163	New
7	ICGV 95165	New
8	ICGV 95172	New
9	ICGV 95179	New
10	ICGV 96066	New
11	ICGV 96073	New
12	ICGV 96084	New
13	ICGV 96100	New
14	ICGV 96107	New
15	ICGV 96108	New
16	ICGV 96110	New
17	ICGV 96234	New
18	Apo	Local variety from Eastern Highlands
19	Topo	Local variety Raikos area, Madang Prov.
20	Yarang	Local variety (crocodile skin)

Results

Trial 1

Pod yields from all the varieties were less than 2 tonnes per ha, most likely due to the prolonged dry weather conditions. However, the following varieties outyielded the local check varieties: ICGVs 95248, 95271 and 94357, all of which are short-duration types. The top 10 varieties are listed in Table 6.

Pod-boring pests were encounted while the crop was maturing. These were mainly small earwigs and click beetles, the identities of which are yet to be determined. Results obtained from this trial appeared to indicate that variety ICGV 95248 had fewer damaged pods than the other varieties (Table 6). These data suggest that there may be varietal differences in susceptibility to these pod-boring pests in the field.

Table 6. Peanut pod yields (unshelled) from top 10 varieties (t/ha) selected from trial 1

Variety	Yield (t/ha)	Bored pods (%)
ICGV 95248	1.87	7.3
ICGV 95271	1.53	20.7
ICGV 94357	1.47	13.7
Yarang	1.40	21.7
Kesowai	1.37	12.0
ICGV 94341	1.37	11.3
ICGV 94299	1.30	12.7
ICGV 95319	1.30	18.3
ICGV 95278	1.23	23.7
ICGV 95256	1.23	22.3
ICGV 95245	1.23	18.7

Trial 2

Pod yields obtained in trial 2 were generally higher than those obtained in trial 1. This difference was mainly due to favourable distribution of rain during the growing season. The highest yields were obtained from variety ICGV 94341 (5.1 t/ha) with a further nine varieties having yields >4 t/ha (Table 7). A number of these varieties appeared in the top 10, including ICGVs 94341, 94299, 95245, 95299 and 95248.

There was a strong positive relationship between yields of trials 1 and 2 (Figure 2), suggesting reasonable stability in genotype performance across seasons. More than 1006 mm rainfall was received during trial 2 compared to 277 mm in trial 1.

Significant differences were observed in varieties for earwig damage with variety ICGV 96470 being highly susceptible and ICGV 95248 highly tolerant (Table 7). The selected varieties based on pod yield have moderate tolerance to earwig damage. Although not statistically significant, a negative relationship was observed for yields from different varieties and bored pods (Figure 3).

Trial 3

Crop emergence varied significantly (P<0.001) at 5 days through to 20 days after sowing (Figure 4). By 14 days after sowing most varieties recorded >80% emergence except for ICGV 96110, 95165 and 96234.

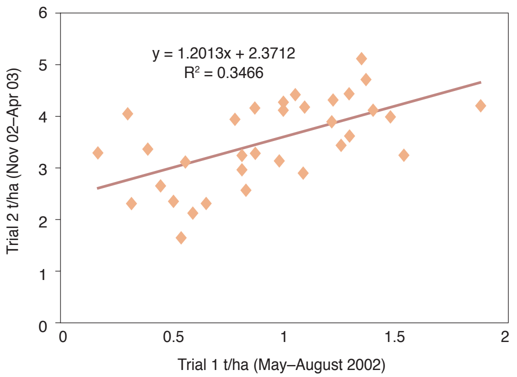

Figure 2. Relationship between peanut yields from trials 1 and 2 at Ramu Sugar, Markham Valley, Papua New Guinea. The differences observed in the trials were mainly due to rainfall received during the growing period.

Table 7. Summary of peanut yields and pest damage in different varieties in trial 2

Code	Variety	Yield (t/ha)	Earwigs (no./plant)	Bored pods %
1	ICGV 94299	4.4 abc	9.3	8.7 cdefg
2	ICGV 94341	5.1 a	4	6.7 defg
3	ICGV 94350	4.2 abcdef	9	23.0 bcd
4	ICGV 94357	4.0 abcdef	13.3	12.3 cdefg
5	ICGV 94358	4.0 abcdef	9.7	13.0 cdefg
6	ICGV 95244	4.1 abcdef	19.3	21.0 bcdef
7	ICGV 95247	4.3 abcd	4	11.7 cdefg
8	ICGV 95248	4.2 abcdef	9.3	3.3 g
9	ICGV 95271	3.2 cdefghij	6.7	12.3 cdefg
10	ICGV 95278	3.9 abcdefg	11.3	21.7 bcde
11	ICGV 95290	3.2 cdefghij	5.3	19.0 bcdefg
12	ICGV 95299	4.3 abcde	10.7	13.7 cdefg
13	ICGV 95319	3.6 bcdefgh	8.7	12.3 cdefg
14	ICGV 95322	4.4 abcd	9.6	12.3 cdefg
15	ICGV 94361	4.1 abcdef	5.3	18.7 bcdefg
16	ICGV 96466	3.1 cdefghij	2.7	20.7 bcdef
17	ICGV 96468	2.9 fghijk	5.7	7.7 defg
18	ICGV 96469	2.6 ghijk	11.3	17.3 cdefg
19	ICGV 96470	3.3 cdefghij	7	45.7 a
20	ICGV 95256	3.5 bcdefghi	4	10.3 cdefg
21	ICGV 92029	2.3 hijk	11.7	5.7 efg
22	ICGV 93115	4.1 abcdef	21.7	6.0 efg
23	ICGV 93123	2.1 jk	10.7	8.0 defg
24	ICGV 93139	2.2 ijk	10.3	5.3 fg
25	ICGV 93143	2.3 hijk	7.3	24.7 bc
26	ICGV 94016	1.7 k	16.3	34.0 ab
27	ICGV 94037	3.4 cdefghij	10.3	11.3 cdefg
28	ICGV 94093	3.1 defghij	11.7	8.7 cdefg
29	ICGV 94094	1.7 k	4.3	9.0 cdefg
30	ICGV 94113	2.3 hijk	7.3	6.3 efg
31	ICGV 94040	3.0 efghijk	8.7	17.0 cdefg
32	Yarang	4.1 abcdef	12	11.0 cdefg
33	Kesowai	4.8 ab	4.3	9.3 cdefg
Mean		3.4	9.2	14.1
LSD (P<0.05)	P<0.001	Ns	P<0.01	
CV %		23	77	70

Means followed by similar letters in each column are not significantly different at LSD (*P*<0.05).

Days to 50% flowering varied significantly amongst varieties with the local variety Apo taking 26 days to 50% flowering while varieties such as ICGVs 95165, 95172, 96100, 96108, 96110 and 96234 took up to 34 days to reach 50% flowering.

Varieties differed significantly for pod yield with yields ranging from 1.7 to 5.9 tonnes ha^{-1} (Table 8). The highest yields were obtained from varieties ICGV 94341, 95172 and 96160 with yields above 5.7 t ha^{-1}. The local variety Apo had the lowest yield with 1.7 t ha^{-1}. Low yields of Apo could be due to noticeable harvest losses (left in the ground). About 80% of the ICGV varieties yielded more than the average of the local varieties (3.3 t/ha), indicating high potential of these varieties in the upper Markham area.

Highly significant differences (*P*<0.001) were observed between different varieties with variety ICGV 96110 having the largest kernels (Table 8). This variety also has acceptable yields (5.5 t ha^{-1}) and therefore it would be an ideal candidate for further multiplication for commercial production. The smallest kernel size was observed in the local variety Yarang.

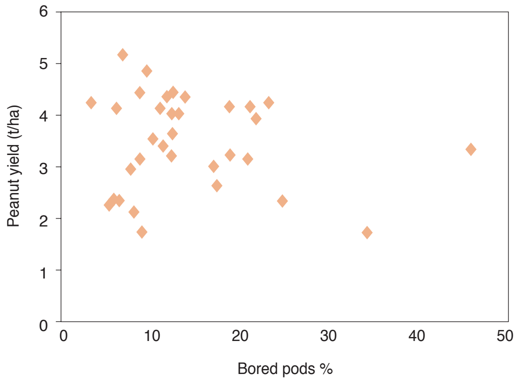

Figure 3. Relationship between earwig damage and peanut yields from different varieties in trial 2

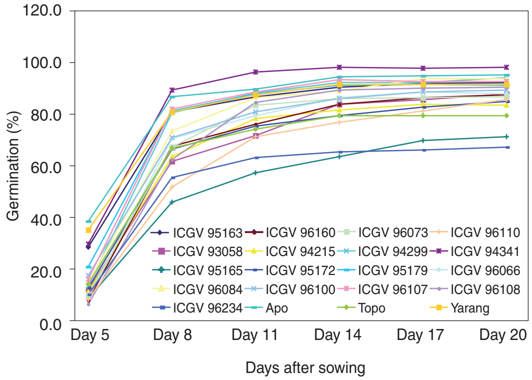

Figure 4. Summary of germination observed in different peanut varieties for trial 3

The varietal differences observed for earwig numbers and bored pods were not significant (Table 8), but there was a significant negative relationship ($r = -0.604$, $P<0.01$, df = 18) between earwig damage and yields (Figure 6a). Variety ICGV 94341 had the lowest damage and also gave the highest yields, while the local variety Apo had the highest damage and lowest yields. The relationship between earwig densities and bored pods was not significant although there was a positive trend (Figure 6b) suggesting possible varietal difference in tolerance to earwig damage.

Table 8. Summary of peanut yields and earwig damage observed in different varieties evaluated in trial 3

Varcode	Variety ID	Pod yield (t/ha)	100 seed weight (g)	Earwigs (no./plant)	Bored pods (%)
1	ICGV 96160	5.7 a	83.6 b	2.0	4.2
2	ICGV 93058	5.4 ab	81.8 bc	3.3	2.5
3	ICGV 94215	4.9 abcd	76.9 bcde	4.8	2.9
4	ICGV 94299	5.5 ab	59.5 gh	3.0	1.4
5	ICGV 94341	5.9 a	50.8 ij	2.2	0.6
6	ICGV 95163	5.2 abc	75.1 cdef	2.3	5.7
7	ICGV 95165	4.6 abcd	80.5 bcd	1.3	1.0
8	ICGV 95172	5.7 a	84.0 b	1.5	1.7
9	ICGV 95179	5.1 abc	55.7 hi	1.8	2.7
10	ICGV 96066	5.3 abc	74.7 cdef	5.3	4.2
11	ICGV 96073	3.2 e	81.9 bc	1.0	1.4
12	ICGV 96084	4.7 abcd	70.5 ef	1.0	0.7
13	ICGV 96100	4.0 cde	84.7 ab	1.5	2.0
14	ICGV 96107	5.2 abc	58.1 hi	3.0	1.9
15	ICGV 96108	5.4 ab	83.4 b	7.3	1.7
16	ICGV 96110	5.5 ab	92.7 a	3.0	2.5
17	ICGV 96234	4.2 bcde	83.8 b	2.3	1.8
18	Apo	1.7 f	73.3 def	4.8	11.9
19	Topo	3.5 de	67.1 fg	3.3	6.7
20	Yarang	4.6 abcde	46.3 j	1.0	1.1
Mean		4.8	73.2	2.8	2.9
Sig #	*	**	**	ns	ns
CV (%)		21	8	126	181

\# * significant at $P<0.05$; ** = $P<0.01$; ns = not significant.

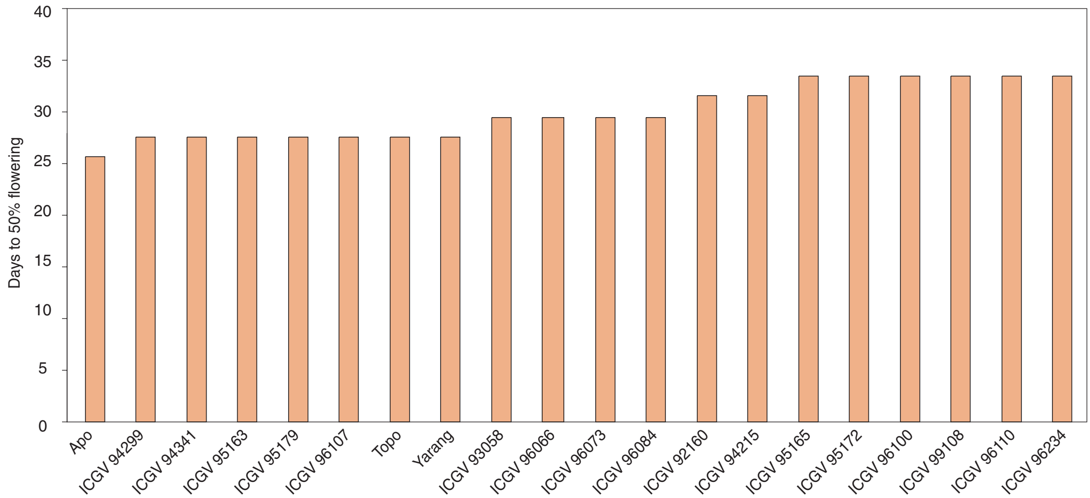

Figure 5. Summary of peanut varietal differences in number of days to 50% flowering

Discussion

During 2003–2004, three varietal trials were conducted at Ramu Sugar. Trials 1 and 2 involved 33 varieties including two local check varieties, while trial 3 involved 20 varieties including three local check varieties. Pod yields varied significantly within and between the three trials. Pod yields ranged from <0.5 to 1.4 t/ha in trial 1, 1.7 to 5.1 t/ha in trial 2 and 1.7 to 5.9 t/ha in trial 3. The yield variation between the trials was mainly due to differences in rainfall distribution during the growing season (see Chauhan et al. 2006, p. 68 in these proceedings).

A number of new varieties have outyielded the local varieties, indicating a potential role for these varieties in improving peanut production. The short-duration varieties took up to 90 days to mature while the medium-duration ones had a longer growth period of more than 120 days. Most of the short-duration varieties have smaller kernels and were also higher yielding; for example the varieties ICGVs 94341 and 94299. Some of the late maturing varieties had large kernels and could be used as snack peanuts, which could attract a higher value.

Almost all the selected varieties have moderate susceptibility to foliar diseases, which was not

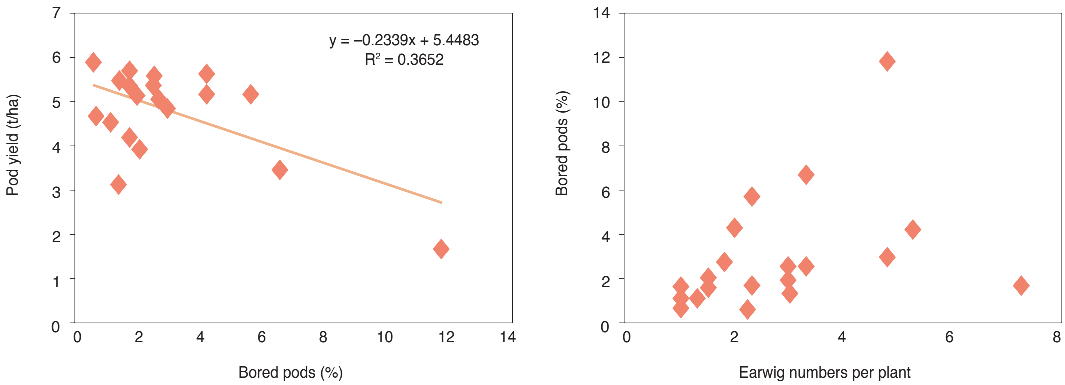

Figure 6. Summary of observations made on earwig damage and peanut yield in trial 3: relationship between bored pods and yield (left); relationship between earwig densities and bored pods (right)

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

Dr Lastus Kuniata inspecting peanut trial at Ramu Sugar, Markham Valley, Papua New Guinea

Table 9. Yield performance of most promising peanut varieties at Ramu Sugar, Markham Valley, Papua New Guinea in three field trials conducted during 2002–2004.

Trial 1		Trial 2		Trial 3	
Genotype	Yield (t/ha)	Genotype	Yield	Genotype	Yield
ICGV 95248	1.9	**ICGV 94341**	5.1	**ICGV 94341**	5.9
ICGV 95271	1.5	**ICGV 94299**	4.8	ICGV 92160	5.7
ICGV 94357	1.5	ICGV 95322	4.4	ICGV 95172	5.6
Yarang	1.4	**ICGV 95245**	4.4	ICGV 96110	5.5
Kesowai	1.3	ICGV 95299	4.3	ICGV 94299	5.5
ICGV 94341	1.3	ICGV 94350	4.3	ICGV 93058	5.4
ICGV 94299	1.3	**ICGV 95248**	4.2	ICGV 96108	5.3
ICGV 95245	1.3	ICGV 94361	4.2		
Expt Mean	0.94	Expt Mean	3.4	Expt Mean	4.7

(NB: the varietal composition of trial 3 was different from trials 1 and 2)

adequately assessed in these trials. If selected varieties are to be distributed to smallholder farmers, then future selections have to address this aspect. Only disease resistant or tolerant varieties will be distributed to smallholders. In commercial situations, appropriate fungicides should be applied.

Conclusions

Table 9 presents the yield performance of the most promising varieties in the three trials at the Ramu Sugar site. It was encouraging to note that some genotypes showed superior performance in the first two trials (identified in bold font) with ICGV 94341 and 94299 performing consistently well in all the three trials. Therefore, these varieties are to be further multiplied for commercial and smallholder distribution.

Acknowledgments

A number of technicians assisted in these trials. Funding for this work was provided by ACIAR (Project No. ASEM/2001/055).

References

Charters C.J. 1981. Land resource assessment for sugarcane cultivation in Papua New Guinea. Applied Geography 1, 259–271.

Chauhan Y., Rachaputi Rao C.N., Wright G., Kuniata L., Ramakrishna A., Tomda Y. and Geob T. 2006. Assessing the potential for rainfed peanut production in Papua New Guinea using crop modelling approaches. These proceedings.

Hartemink A.E. 1998. Soil chemical and physical properties as indicators of sustainable land management under sugar cane in Papua New Guinea. Geoderma 85, 283–306.

Crop husbandry practices for peanut growing in the upper Markham Valley, Papua New Guinea

Lastus S. Kuniata[1], Miriam Otto[1], Rebecca Bogosia[2] and John Mondo[3]

[1]*Ramu Sugar Ltd, PO Box 2183, Lae 411, Morobe Province, Papua New Guinea; email: lkuniata@ramusugar.com.pg*

[2]*University of Vudal, PMB Service, Rabaul, East New Britain Province, Papua New Guinea*

[3]*Agriculture Department, PNG University of Technology, PMB Lae, Morobe Province, Papua New Guinea*

Abstract

Sustainable production of peanuts in the Markham Valley will require better agronomic practices. A number of trials were established at Ramu Sugar to determine appropriate plant densities, fertiliser requirement and herbicides to be used in peanuts. The results from the plant density trials showed no significant differences in yields between the different planting densities. In a fertiliser trial established to evaluate different rates of phosphorus, potassium and lime the results showed a highly significant (P<0.01) effect of lime application. The data from the herbicide trial showed that diuron and atrazine should not be used as these have a severe phytotoxic effect on peanuts. Preliminary studies indicated that Flame+Gramoxone application gave the best weed control.

Introduction

The soils on the Ramu Sugar estate, Markham Valley, Papua New Guinea (PNG) are derived from alluvial deposits of the Ramu River and its tributaries. Soil chemical and physical properties have been discussed in detail by Hartemink (1998). Common soil types are Fluvisols, which are characterised by having clear stratification, Vertisols, which have heavy clays that swell and shrink during wet and dry seasons, and Phaeozems, which have thick, black topsoils. Gleysols, which have stagnating water during the rainy season, occur in some parts of the estate (Charters 1981). Similarly, small areas to the east have Allofane soils. Soil pH is between 5.8 and 6.8, and there is no apparent risk of exchangeable aluminum or excess $CaCO_3$. Salinity is not a problem in the topsoil.

There is little information on fertiliser application for peanuts in PNG. Observations made at Ramu showed that peanuts grown in plots with filter mud (a by-product from the sugar processing factory) produced a higher pod yield than those in plots without this treatment. Since phosphate and potassium content are usually high in filter mud, it was likely that this treatment may have influenced peanut yields. Application of P and K as fertilisers will be critical in sustaining peanut yields under Ramu/Markham soil conditions.

Plant spacing is an important factor in determining pod yield and kernel size in peanut. The optimum plant density differs depending on the growth habit of the genotype. Therefore it is necessary to determine optimum planting densities for these varieties for production under Ramu conditions.

Itch-grass (*Rottboellia cochinchinensis*), nut-grass (*Cyperus rotandus*) and *Ipomea* sp. vine are major weeds at Ramu Sugar. Management of these weeds in a fallow situation is necessary for reducing weed competition in subsequent sugarcane crops.

Sustainable production of peanuts at a commercial scale will require good crop husbandry practices. As large-scale farming will have to be undertaken for a profitable industry, mechanisation of most operations will be necessary. Peanut rotation with sugarcane in the upper Markham Valley will not only provide invaluable crop rotational benefits but also increased profits.

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

Material and methods

Fertilizer trial

The fertiliser trial was laid out as a 2 × 4 × 4 factorial design with three replicates at the Ramu Sugar site. The trial was planted on 7–8 April 2005 and harvested at the end of July 2005. There were two liming treatments (0 and 100 kg/ha), each with four levels of P and four levels of K (Table 1). Triple superphosphate (TSP, 18% P) was used as a source of P and muriate of potash (MOP, 50% K) was used to supply K. All treatments (Table 1) were manually applied as basal treatments before planting. The total plot size was 2 m × 4 m and yield data were recorded from an area of 1.2 m × 4 m. The local variety Yarang was used in the trial. Before planting, all the seeds were treated with acephate (insecticide) and thiram (fungicide) at a rate of 1 g product/kg seed. Pest and disease control were applied when necessary following field inspection. The data collected included days to 50% flowering, dry-matter yield at harvest and yield.

Table 1. The fertiliser treatments applied in the peanut growth trial. Treatment codes 1–16 did not receive basal lime while 17–32 received a basal dose of lime at 100 kg/ha.

Treatment code	No lime	Treatment code	With lime 100 kg/ha
1	P0K0	17	P0K0
2	P0K15	18	P0K15
3	P0K30	19	P0K30
4	P0K45	20	P0K45
5	P9K0	21	P9K0
6	P9K15	22	P9K15
7	P9K30	23	P9K30
8	P9K45	24	P9K45
9	P18K0	25	P18K0
10	P18K15	26	P18K15
11	P18K30	27	P18K30
12	P18K45	28	P18K45
13	P36K0	29	P36K0
14	P36K15	30	P36K15
15	P36K30	31	P36K30
16	P36K45	32	P36K45

Plant density trial

The treatments used are given in Table 2. Variety Yarang (local) has a bunch growth habit while ICGV 96100 is a semi-spreading type. The trial was laid out as a split-plot design with three replications, with the varieties as main-plots and plant densities as sub-plots. The trial was planted on 14 April 2005 and harvested in the last week of July 2005. Plot sizes used were 2.4 m × 5 m. Acephate and thiram were used as seed treatment at 1 g product/kg seed. A top-dressing of 100 kg of TSP/ha and 60 kg of MOP/ha fertilisers were applied when the plants were 4 weeks old. Pest and disease control were applied when necessary following field inspection. The pod yield was recorded at harvest.

Table 2. Treatments used in the peanut plant density trial

Treatment code	Variety	Density (plants/ha)	Spacing (cm)
T1	Yarang	250,000	10 × 40
T2	Yarang	166,670	15 × 40
T3	Yarang	125,000	20 × 40
T4	Yarang	100,000	25 × 40
T5	Yarang	83,330	30 × 40
T6	ICGV 96100	250,000	10 × 40
T7	ICGV 96100	166,670	15 × 40
T8	ICGV 96100	125,000	20 × 40
T9	ICGV 96100	100,000	25 × 40
T10	ICGV 96100	83,330	30 × 40

Herbicide trial

The trial was established in mid-November 2004 to evaluate various residual herbicides already being used in sugarcane that could also be used in peanuts. The main weed species was *Rottboellia cochichinensis.*

The trial was laid out as a randomised complete block design with six weed control treatments (Table 3) replicated four times. The plot size was four beds of 10 m length × 1.8 m width. Plantings were done on beds, with two rows of peanuts per bed. The herbicide treatments were applied after planting using a CP3 knapsack calibrated to give 150 litres spray volume per ha. The soil was moist when the treatments were applied.

Table 3. Herbicide treatments used (kg product/ha) in the peanut growth trial

Terbutryn, 4 kg
Terbutryn, 6 kg
Terbutryn, 4 kg + atrazine, 3 kg
Terbutryn, 6 kg + atrazine, 3 kg
Gramoxone (paraquat), 1 L + diuron, 1 kg
Hand weeding

The yield data were collected from the two centre beds leaving out the two outer rows as guards. The phytotoxic effect on peanut was assessed by counting

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

dead plants. A visual score of 1–10 scale (1 meant no control and 10 meant complete weed control) was used to assess the weed cover.

Results and discussion

Fertiliser trial

Although soil moisture conditions at the time of sowing were ideal, emergence was slow. At 10 days after planting, plots treated with lime had significantly (P<0.05) higher germination than the plots without lime. Neither the phosphorus nor potassium treatments had a significant influence on germination. The differences were highly significant (P<0.001) at 15–30 days after planting with lime application but not with phosphorus and potassium application. The treatments did not influence time to 50% flowering (Table 4).

The study demonstrated the importance of lime application in crop establishment. Further work may be necessary to determine the economics of lime application. The trial plot received about 80 t/ha of mill-mud in 2003 and it is possible that the residual effect of P and K in mill mud resulted in lack of response to fertilisers in this trial.

Table 4. Summary of germination observed for peanut plots treated with lime

Days after planting	Germination (%)		Significant difference	Coefficient of variation
	No lime	With lime		(%)
5	43.8	41.0	ns	26.7
10	58.1	61.8	*	12.3
15	61.8	67.9	***	10.9
20	64.1	70.8	***	9.4
25	69.8	75.5	***	6.8
30	73.0	75.5	***	5.6

Note:
ns = not significant, * = significant at P<0.05;
*** = significant at P<0.001.

The peanut stand at harvest was excellent (>80% establishment). The yield differences between the fertiliser treatments were not significant. However, a highly significant (P<0.001) positive response was observed for the liming treatment (Tables 5(a) and (b), Figure 1). In general, plots that received lime had 32% greater yield than control plots. The highest yields and gross returns were observed with application of lime, but not with potassium application (Table 5a).

Table 5(a). Response of peanut yields to liming and potassium application

Potassium (kg/ha)	Yield (t/ha) No lime	Yield (t/ha) With lime	Yield (t/ha) increase	Kina additional*
0	1.78	2.64	0.86	1144
15	1.83	2.18	0.35	466
30	1.69	2.45	0.76	1011
45	2.00	2.38	0.38	505

Table 5(b). Response of peanut yields to liming and phosphorus application

Phosphorus (kg/ha)	Yield (t/ha) No lime	Yield (t/ha) With lime	Yield (t/ha) increase	Kina additional*
0	2.10	2.38	0.28	372
9	1.88	2.46	0.58	771
18	1.67	2.45	0.78	1037
36	1.67	2.37	0.70	931

* At K40 per 30 kg bag.

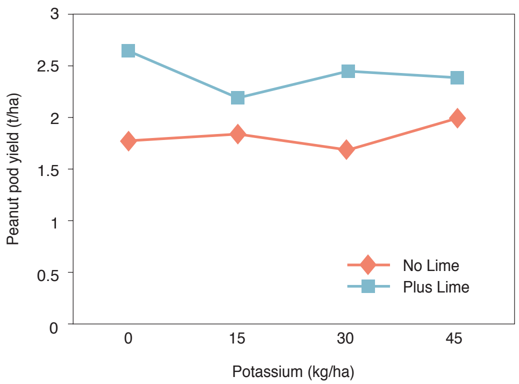

Figure 1. Summary of the effect of lime and potassium on yields of peanuts

As for potassium, the application of phosphorus did not have any effect on pod yield (Table 5b). Interestingly, addition of phosphorus alone (without lime) resulted in a decline in yield (Table 5b and Figure 2a), while there was a marginal increase in yield with the addition of 9 kg or 18 kg phosphorus with lime. Given these data, it appears that phosphorus applied at 9–18 kg/ha with lime (100 kg lime per ha) should be recommended in commercial planting of peanuts at Ramu Sugar.

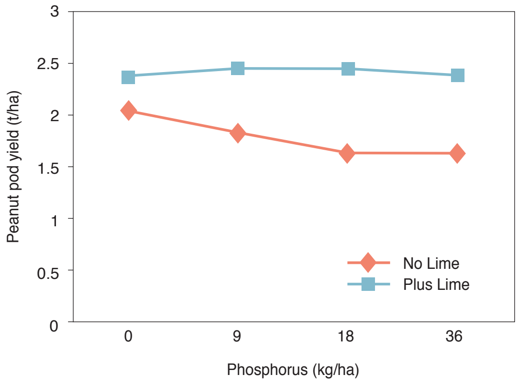

Figure 2 (a). Effect of lime and phosphorus on peanut yield

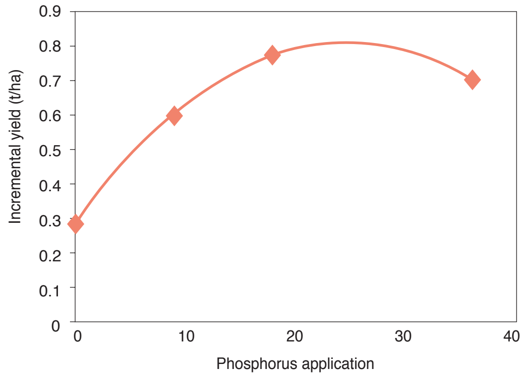

Figure 2 (b). Effect of liming + phosphorus fertilisers on peanut yield

Other observations made on percentage of mature pods and earwig damage (bored pods) did not show any significant difference between the treatments.

Plant density trial

In both varieties (Yarang and ICGV 96100) yields were highest at a plant density of 250,000/ha, although the yield differences between the plant density treatments were not statistically significant. At harvest, yields of ICGV 96100 were generally higher than Yarang but these differences were not statistically significant (Table 6). The total dry matter produced by ICGV 96100 was significantly greater than the local Yarang variety at all plant density levels. Except for total dry weight, the other variables were not statistically significant.

However, the final plant population at harvest was variable with some treatments recording 20–30% deviation from the targeted population. Therefore the trial needs to be repeated.

Table 6. Summary of peanut yields and other data from the plant density trial

Variety	Plant density (No./ha)	Peanut yield (t/ha)	Total dry weight per plot (kg)	Pods/plant (no.)	Mature pods/ plant (%)	Bored pods (%)
Yarang	250,000	1.33	6.8 ab	13.8	39.7	3.0
	167,000	1.27	7.3 ab	16.8	48.3	13.0
	125,000	1.25	5.4 bc	11.8	33.0	3.0
	100,000	1.27	4.4 c	17.2	45.3	10.7
	83,000	1.13	5.7 bc	18.4	73.3	5.0
ICGV 96100	250,000	1.92	10.0 a	16.2	66.0	8.0
	167,000	1.46	8.5 ab	14.2	50.0	5.3
	125,000	1.73	7.4 ab	15.2	54.7	4.0
	100,000	1.79	8.5 ab	14.3	57.3	3.7
	83,000	1.56	5.4 bc	15.7	61.7	10.3
Mean	—	1.47	6.9	15.3	52.9	6.6
lsd (P<0.05)	—	ns	*	ns	ns	ns
CV (%)	-	27.3	20.1	24	25	81

Note:
ns = not significant ; * = significant at P<0.05
Data with similar letters in each column are not significantly different at LSD *P*<0.05.

Table 7. Effect of herbicides on the crop emergence and seedling mortality of Yarang variety peanuts. Markham Valley, Papua New Guinea grown at Ramu Sugar

Details (product/ha)	Days after planting* 5	8	11	14	17	20	% surviving plants
Terbutryn, 4 kg	1	132	262	278	277 a	286 a	95.3
Terbutryn, 6 kg	1	150	263	278	276 a	280 a	93.3
Terbutryn, 4 kg + atrazine, 3 kg	2	154	261	274	123 b	126 b	42.0
Terbutryn, 6 kg + atrazine, 3 kg	4	158	259	274	92 c	85 b	28.3
Gramoxone, 1 L + diuron, 1 kg	2	150	269	273	269 a	283 a	94.3
Hand weeding	3	150	261	279	277 a	287 a	95.7
Mean	2.1	149	263	276	219	225	—
LSD (P<0.05)	ns	ns	ns	ns	<0.001	<0.001	—
CV %	90	8.8	2.9	2.9	8	13.3	—

* Data followed by the same letter in each column are not significantly different at P<0.05.

Herbicide trial

The results from the herbicide trial showed that although crop establishment was satisfactory up to 2 weeks after planting in all treatments, significant seedling mortality occurred in some treatments after 2 weeks from sowing (Table 7). Seedling mortality was the highest with terbutryn + atrazine treatments compared to terbutryn alone. At 20 days after planting there was 60–70% plant mortality in the terbutryn + atrazine treatments resulting in less than 30% of surviving plants compared to other treatments in which >90% of the plants survived (Table 7)

Although the terbutryn + atrazine treatment gave complete weed control, its phytotoxic effect on the crop was also highly significant (Table 8 and Figure 3). Hand weeding followed by terbutryn at 4 and 6 kg/ha resulted in yields well above 1.0 t/ha compared to <0.4 t/ha in terbutryn + atrazine treatments.

Terbutryn + atrazine treatment is used in sugarcane for the control of grass- and broad-leaf weeds. In sugarcane this treatment can provide up to 6 weeks control. However, this study demonstrated that the combination of terbutryn and atrazine cannot be used for peanuts.

Post emergence application of Flame (imazapic) + Gramoxone is commonly used in Queensland to control severe infestation of nut-grass (*Cyperus rotundus*) in standing peanut crops. A preliminary study was conducted at Ramu Sugar to study the effect of a

Table 8. Summary of weed infestations in peanut plantings recorded in various herbicide treatments. The main weed species encountered was itch-grass (*Rottboellia cochinchinensis*).

Details (product/ha)	One week after planting			Two weeks after planting			Three weeks after planting		
	Weed density *	Weed cover score **	Damage score ***	Weed density	Weed cover score	Damage score	Weed density	Weed cover score	Damage score
Terbutryn, 4 kg	8	9	1.8	11	8.5	1.0 c	14.3	4.5 bcd	1.0 c
Terbutryn, 6 kg	12.5	8	2.5	14.3	7.8	1.3 c	17.5	4.0 cd	1.8 c
Terbutryn, 4 kg + atrazine, 3 kg	7.3	9.3	1.8	10.5	8.8	5.5 a	13.3	6.3 ab	6.3 b
Terbutryn, 6 kg + atrazine, 3 kg	6.8	9.3	1.8	7	9	6.5 a	9.3	7.8 a	9.5 a
Gramoxone, 1 L + diuron, 1 kg	6.3	9.5	1	11.3	8.3	2.5 b	14.5	5.5 bc	2.0 c
Hand weeding	10	8.5	1.5	12.5	8	1.3 c	15.8	2.8 d	1.0 c
Mean	8.5	8.9	1.7	11.1	8.4	3	14.1	5.1	3.6
LSD (P<0.05)	ns	Ns	ns	ns	ns	<0.001	ns	<0.01	<0.001
CV %	63	10.3	54	43	11	27	37	27	24

Notes
* Weed density is number of weeds per sq m
** Weed cover score is where a score of 1 is no control of weeds, 10 is complete control of weeds
*** Damage score is for peanut plant damage by herbicides. A score of 1 means no damage, 10 means dying or dead plants
Means followed by same letter in each column are not significantly different at P<0.05.

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

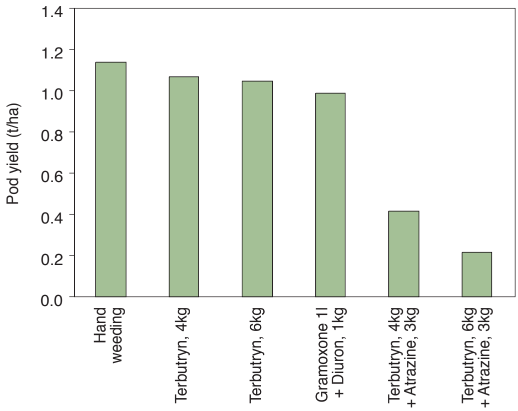

Figure 3. Effect of different herbicide treatments on yield of peanut grown at Ramu Sugar

post-emergence application of Flame and Gramoxone on weed control in peanut crops. Flame (500 mL/ha) and Gramoxone (2 L/ha) were used in the study. This treatment provided satisfactory control of nut grass although it had a moderately phytotoxic effect on the peanut crop which lasted for 2–3 weeks.. This treatment was used in two other seed multiplication blocks and again proved to be effective against nutgrass, *Rottboellia cochinchinensis, Ipomoea* sp. vine and pig-weed.

Conclusions

The results of the fertiliser trial indicated that the application of lime is critical for peanut crop establishment. Although there was no significant effect of potassium, a yield response was observed for application of 9–18 kg P/ha, in combination with lime.

The plant density trial did not show any significant differences in yield. However, the trial needs to be repeated after standardising the methods to achieve the target plant population using the mechanised peanut planter. Similarly, more work is required on evaluating herbicides for control of weeds in peanut crops. Although Flame + Gramoxone seem to provide effective weed control, this treatment needs to be further evaluated in larger blocks in comparison with other herbicides.

Acknowledgments

Funding for this work was provided by ACIAR (Project No. ASEM/2001/055). David Ekiha and other research assistants helped with the field work.

References

Charters C.J. 1981. Land resource assessment for sugar-cane cultivation in Papua New Guinea. Applied Geography 1, 259–271.

Hartemink A.E. 1998. Soil chemical and physical properties as indicators of sustainable land management under sugar cane in Papua New Guinea. Geoderma 85, 283–306.

Ramu Sugar and Australian project team with a new peanut planter at the Ramu estate, Markham Valley, Papua New Guinea

Assessing the potential for rainfed peanut production in Papua New Guinea using crop modelling approaches

Yash Chauhan[1], Rao C.N. Rachaputi[1], G.C. Wright[1], Lastus Kuniata[2], A. Ramakrishna[3], Yanding Tomda[3] and Timothy Geob[3]

[1]*Department of Primary Industries and Fisheries, PO Box 23, Kingaroy, Queensland 4610, Australia; email: yash.chauhan@dpi.qld.gov.au*

[2]*Ramu Sugar Ltd, PO Box 2183, Lae 411, Morobe Province, Papua New Guinea*

[3]*National Agricultural Research Institute, PO Box 210, Aiyura, Eastern Highlands Province, Papua New Guinea*

Abstract

Application of crop simulation models in combination with long-term climate data allows assessment of the peanut production potential, appropriate management, varietal options and possible climatic constraints for productivity and quality for a given environment. As a part of the ASEM 2001/55 project, the Agricultural Production Systems Simulator (APSIM) peanut model was used as a tool to assess the yield potential and quality constraints of peanut in three targeted peanut production regions (Aiyura, Bubia and Ramu Sugar) in Papua New Guinea. The model predicted pod yield satisfactorily for Bubia and Ramu Sugar sites, but poorly at the Aiyura site, possibly due to unknown site specific constraints. The long-term scenarios indicated a potential for year round production of peanuts in all three regions, which could be realised provided appropriate crop rotations/practices are followed to minimise the impact of climatic constraints. The model also suggested that rainfed peanut crops sown between April and June at Ramu Sugar may have increased risk of aflatoxin. Overall, the study showed that the APSIM peanut model can be used as a tool to assess the production potential of peanuts at various planting times and associated aflatoxin risk in the target environments.

Introduction

In Papua New Guinea (PNG) peanuts are generally grown under marginal input conditions in backyard gardens for sale in local roadside markets as well as for domestic consumption. There is, however, little published information on yield potential and quality of peanuts produced in the country. A recent farmer survey conducted as part of the ASEM 2001/55 project noted that peanut yields in PNG are low (average 0.9 t/ha) and variable (Wemin and Geob 2004). Limited field trials conducted in the project demonstrated significant scope for yield improvement by implementing appropriate management and varietal options (see Ramakrishna et al. 2006; Kuniata et al. 2006; and Saese et al. 2006 in these proceeding). However, conducting large-scale, multi-location field trials in PNG is not only resource intensive but is difficult to achieve owing to infrastructure problems. Application of crop simulation models in combination with long-term climate data can allow an assessment of the peanut production potential, appropriate management and variety options and possible climatic constraints for productivity and quality for a given environment. The peanut module of the Agricultural Production Systems Simulator (APSIM) developed by the Agricultural Production Systems Research Unit can simulate crop growth and yield using daily weather (Hammer et al. 1995; Robertson et al. 2002) and is being extensively used to predict potential yields and aflatoxin risk in various production systems (Wright et al. 2005). The APSIM peanut model has, however, not been previously applied to simulate peanut crops in PNG environments. One of the objectives of the ASEM 2001/55 project has therefore been to validate the APSIM peanut model for rainfed PNG environments and apply it as a tool to assess the peanut yield potential and quality constraints in three targeted peanut production regions (Aiyura, Bubia and Ramu Sugar) in PNG.

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

Material and methods

There were two steps in applying the peanut crop modelling approach to the PNG peanut industry. Firstly, the APSIM peanut model was validated using the climate and pod yield data obtained from the ACIAR project field trials conducted during the 2003–05 seasons at Aiyura (–6.3°S), Bubia (–6.6°S) and Ramu Sugar (–6.0°S) sites. Secondly, the model was applied using historical climate data from these sites to simulate pod yield and aflatoxin risk scenarios for peanut crops sown at different planting times.

Maximum and minimum temperatures and rainfall records from 1977 to 2005 for Aiyura, from 1984 to 2005 for Bubia, and from 1979 to 2005 for Ramu Sugar were accessed and updated. The APSIM peanut model also requires an input of daily solar radiation data, which generally were not available for PNG environments. This necessitated development of an empirical model to simulate solar radiation for the targeted environments. Where sunshine-hours data were available, these values were converted into solar radiation using the following equation:

$$S = [a_s + b_s \times (n/N)]\ S_0$$

where S is the incident solar radiation at crop level (MJ/m^2/d), a_s is the fraction of extraterrestrial radiation on overcast days (0.25), b_s is the fraction of extraterrestrial radiation on clear days (0.50), n is bright sunshine hours per day, N is total day length, and S_0 is extraterrestrial radiation (MJ/m^2/d). Where sunshine hours data were not available, radiation data were generated using a derived empirical relationship between solar radiation and pan evaporation (Figure 1).

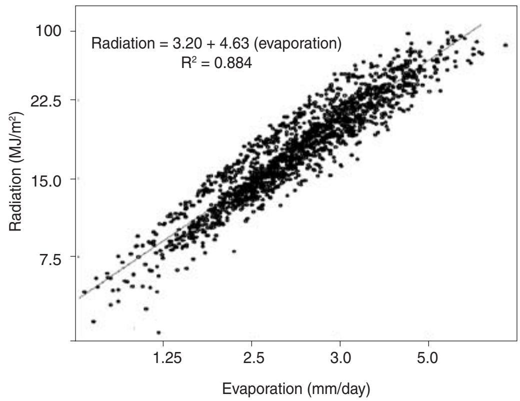

Figure 1. Relationship between solar radiation and open pan evaporation at Aiyura, Papua New Guinea. This relationship was established after removing a few outliers.

The soil parameter file was developed based on the existing knowledge about the soils of the target environments, assuming 120 mm plant available water holding capacity. Soil temperature is a critical input parameter for predicting aflatoxin risk in peanut, which was simulated using the APSIM soil temperature module in conjunction with the peanut module (Y.S. Chauhan et al. 2006, unpublished data).

For model validation, outputs were generated using the seasonal weather and crop management information (actual sowing and harvest dates, plant density of 25 plants/m^2) from the short and medium-duration varietal trials conducted at the Aiyura, Ramu Sugar and Bubia sites. The long-term scenarios of pod yield and aflatoxin risk were simulated for monthly sowing dates using a typical short-duration cultivar with a crop duration of 110 days. The outputs were then compiled into an access database and plotted using the APSIM Outlook software.

Results and discussion

Model validation

The model simulated pod yield for short and medium-duration varieties satisfactorily for the Bubia and Ramu Sugar sites (Figure 2). However, the predicted pod yield potential was much higher than the observed yield (particularly for medium-duration varieties) at the Aiyura site (Figure 2). The yield gap (defined as the gap between predicted and observed

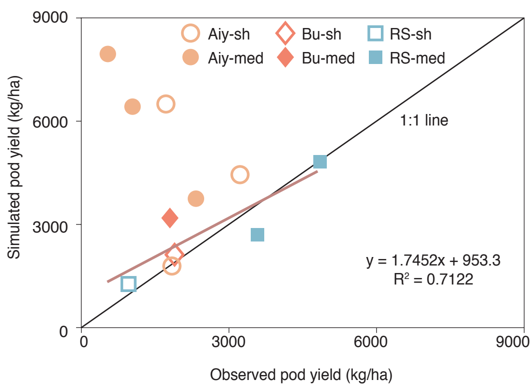

Figure 2. Observed (mean yield of trial) and simulated rainfed pod yields of peanut crops at Aiyura (Aiy), Bubia (Bu) and Ramu Sugar (RS), Papua New Guinea, during the 2002–04 seasons for short (sh)- and medium (med)-duration cultivars. The regression uses only Bubia and Ramu Sugar data. Open symbols are for short-duration genotypes and solid symbols for medium-duration genotypes.

yields) was greater (75%) for medium-duration cultivars than for short-duration cultivars (47%), suggesting that local specific constraints for achieving the yield potential occurred at this location. A yield gap was also apparent at Ramu Sugar and Bubia, but it was much smaller than the one at Aiyura (Figure 2). It should be noted that the current version of the APSIM peanut model does not account for yield losses due to pests, diseases and nutrient disorders, and thus the high yields predicted by the model may not always be realised because of local specific constraints (i.e. biological or soil-related physical or nutrient disorders).

A number of factors could have led to a larger yield gap at the Aiyura site. For example, it is possible that soil constraints such as poor drainage and soil nutrient disorders could be playing a role. It was apparent from the long-term weather data that mean in-season rainfall was much higher for Aiyura (1077 mm) compared to Bubia (977 mm) and Ramu Sugar (689 mm), suggesting possible waterlogging problems at the Aiyura site. It is well known that waterlogging can severely affect functioning of nodules and pod development.

Analysis of the relationship between predicted and observed days to maturity showed there were major differences between sites in days to crop maturity. At the Bubia and Ramu Sugar sites, the days to maturity for short and medium-duration varieties were 100 and 130 days, respectively. The model could predict crop maturity reasonably well for these two sites, except for one trial at Ramu Sugar, where harvesting was delayed by two weeks due to unfavourable weather conditions (Figure 3). However, at the Aiyura site, the predicted days to maturity was 30–60 days longer than the actual harvested date, implying possible premature harvest of the crop.

Production potential and aflatoxin risk scenarios for rainfed peanuts

Long-term weather records of Aiyura, Ramu Sugar and Bubia sites were used to assess production potential and aflatoxin risk for peanuts grown under rainfed conditions. The model outputs showed that year round production of peanut is possible at all three locations although there were strong temporal trends for yields and aflatoxin risk (Figure 4). At the Aiyura and Ramu Sugar sites, time of sowing had a significant effect on pod yield potential and aflatoxin risk. The optimum sowing time for Aiyura and Ramu Sugar was around October/November and yields were the lowest for sowings between April and June. There was no pre-harvest aflatoxin risk at Aiyura, although a high aflatoxin risk was predicted at Ramu Sugar for rainfed crops sown between March and July.

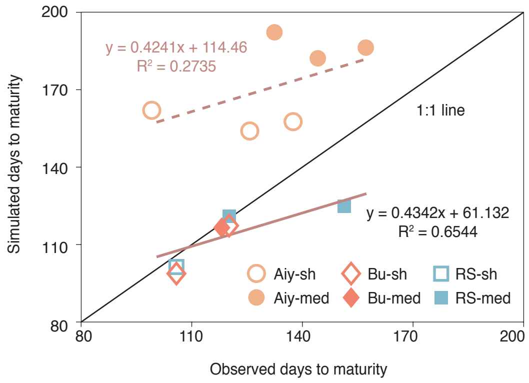

Figure 3. Observed (harvest date of trial) and simulated days to maturity of peanut crops at Aiyura (Aiy), Bubia (Bu) and Ramu Sugar (RS), Papua New Guinea, during the 2002–04 seasons for short (sh) and medium (med) duration cultivars. The lower regression line uses only Bubia and Ramu Sugar data and the upper regression line uses only Aiyura data. Open symbols are for short-duration genotypes and solid symbols for medium-duration genotypes.

For Bubia, the response to sowing time was less defined, suggesting that peanut crops could be grown successfully throughout the year. However, there was large year to year variability in pod yield (except for April–May-sown crops), which was mainly driven by rainfall. There was some (very low) risk of aflatoxin, with no consistent pattern evident.

The modelling approach was useful to simulate production potential for the target environments, to show what could be achieved if local production constraints are alleviated. There may also be some scope to improve yields and minimise aflatoxin risk by sowing crops at optimum time and using the appropriate variety to suit season length and exploit the production potential of the environment.

Implications of crop modelling approach for peanut production in Papua New Guinea

The work done under this project has demonstrated that the APSIM peanut model can be used as a tool to assess the production potential of peanuts in various planting times in the target environments of PNG. The model was also useful in suggesting appropriate planting times and in identifying the size of the yield gap (difference between simulated and observed yield) at each site. The yield gap was largest at Aiyura, and in particular for medium-duration cultivars. The model showed that year round production of peanuts is possible in all the three environments

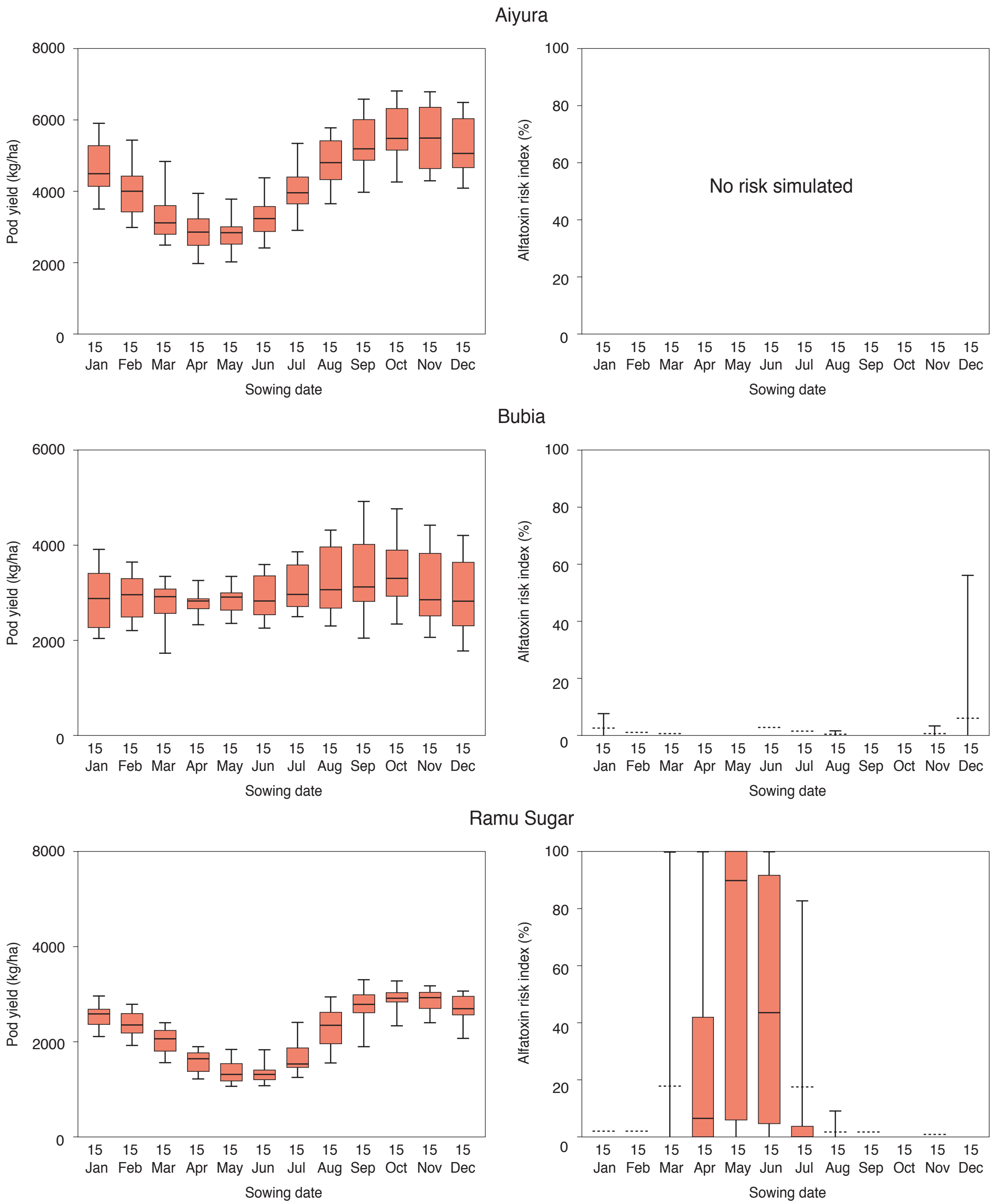

Figure 4. APSIM peanut model simulations of pod yield (kg/ha) and aflatoxin risk index for a typical short-duration peanut genotype sown at monthly intervals at Aiyura (top), Bubia (middle) and Ramu Sugar (lower), Papua New Guinea. The height of the 'red box' and the height of the 'whiskers' indicate the degree of 'variation' or 'riskiness' of a scenario. The size of the box represents 40% variation and each whisker on either side represents 10% variability. The results outside of this range represent the remaining 20% variability. The solid and dashed lines across the box represent median and mean, respectively.

but this is only practical if appropriate crop management practices are followed.

The peanut model can also help in simulating crop maturity so that appropriate varieties that suitably match season length in the various cropping systems could be identified. According to the model, some sowings (e.g. April to June sowings at Ramu Sugar) may have increased risk of aflatoxin. There was also a random chance of aflatoxin risk at the Bubia site. The risk of aflatoxin was somewhat less for short-duration cultivars. From the scenario analysis it was apparent that short-duration cultivars are most suited to Aiyura environments and reasonable yields could be achieved if specific local conditions are managed.

References

Hammer G.L., Sinclair T.R., Boote K.J., Wright G.C., Meinke H. and Bell, M.J. 1995. A peanut simulation model: I. Model development and testing. Agronomy Journal 87, 1085–1093.

Kuniata L.S., Otto M., Bogosia R. and Mondo J. 2006 Crop husbandry practices for peanut growing in the upper Markham Valley, Papua New Guinea. (These proceedings).

Ramakrishna A., Wemin J.M., Geob T., Tomda Y., Rachaputi RCN and Wright G.C. 2006. Selection of peanut varieties suitable for the highlands of Papua New Guinea (These proceedings).

Robertson M.J., Carberry P.S., Huth N.I., Turpin J.E., Probert M.E., Poulton P.L., Bell M., Wright G.C., Yeates S.J. and Brinsmead R.B. 2002. Simulation of growth and development of diverse legume species in APSIM. Australian Journal of Agricultural Research 53, 429–446.

Saese H., Fahey G. and Bafui J. 2006. Evaluation of peanut (*Arachis hypogaea* L.) varieties in the lower Markham Valley of Papua New Guinea. (These proceedings).

Wemin J.M. and Geob T. 2004. Peanut production, utilisation and marketing in Papua New Guinea: a peanut farmer survey. Project report for ACIAR Project ASEM 2001/055. National Agricultural Research Institute, Aiyura, Papua New Guinea.

Wright G., Rachaputi N, Chauhan Y. and Robson A. 2005. Increasing productivity and quality of peanuts using novel crop modeling and remote sensing technologies. In 'Prospects and emerging opportunities for peanut quality and utilisation technology', International Peanut Conference, Kasetsart University, Bangkok, Thailand. 9–12 January 2005, pp. 14-17.

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

Procedures and protocols to maintain purity and viability of peanut (groundnut) germplasm

H.D. Upadhyaya, R.P.S. Pundir, Sube Singh and C.L.L. Gowda

Genetic Resources, International Crops Research Institute for the Semi-Arid Tropics, Patancheru-502 324, Andhra Pradesh, India

Abstract

Successful genebank operations should ensure that pure and healthy seeds are maintained for utilisation in crop improvement and conserving for posterity. Maintaining peanut germplasm in the genebank requires considerable attention. Some protocols followed to maintain purity and viability of peanut germplasm are outlined in this paper. Some distinct measures required for maintenance of peanut germplasm are: (i) raising the peanut crop in well drained light soils, (ii) growing a minimum of 160 plants per accession to retain genetic integrity, (iii) verification of accessions' identity at various stages of crop growth to remove off-type and diseased plants, (iv) harvesting crop at optimum maturity to obtain healthy seeds, (v) avoiding exposure of the freshly harvested pods to strong sunlight (temperature >40°C) to maintain seed viability in storage, (vi) avoiding damage while picking and shelling of pods manually, (vii) conserving seeds at appropriate moisture content, in medium term (4°C; 30% RH) at 7% and in long term (-20°C) at 3–5% and (viii) monitoring of seed stock, viability and health at regular intervals to assess the need for regeneration.

As part of the Australian Centre for International Agricultural Research (ACIAR) project ASEM 2001/055, ICRISAT supplied 46 peanut (groundnut) breeding lines for evaluation in Papua New Guinea (PNG) environments to identify varieties with superior yield and quality over the local check which could be introduced for cultivation in PNG. It is critical that the PNG organisations take responsibility for maintaining genetic purity of the newly introduced peanut germplasm. This paper describes the procedures and protocols that are followed at ICRISAT for maintaining the genetic purity of peanut germplasm. These lines can be maintained by following the procedures described in this paper.

Introduction

Peanut or groundnut (*Arachis hypogaea* L.) is the third largest oilseed crop after soybean and seed cotton, globally. Peanut was cultivated on more than 24 m ha annually during the 2002–04 triennium, producing more than 35 Mt and with productivity of about 1437 kg ha^{-1} peanut-in-shell (FAO 2002–04). As well as producing edible oils, peanut seeds are rich in protein. About two-thirds of world peanut production is used to extract oil and the remainder is in the form of protein-rich, edible products. Peanut is native to southern Bolivia and north-western Argentina. Sixty-nine species are known to occur in the genus *Arachis*, which have been classified into nine sections. Peanut is a tetraploid ($2n = 40$) while some wild species are diploid too. It is a highly self-pollinated crop. In many countries, peanut is grown by smallholder farmers as a cash crop. The value of genetically pure and viable germplasm seed for use in crop improvement is well recognised.

The genebank of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) holds 14,966 accessions of cultivated *Arachis* spp. and about 453 of wild *Arachis*. The advanced/elite breeding lines and/or germplasm lines are supplied to needy countries by ICRISAT under appropriate agreement (Material Transfer Agreement) for evaluation and release to peanut growers. During 2001–02, as a part of the ACIAR project ASEM 2001/055, ICRISAT supplied 46 (20 short-duration; 26 medium-duration) elite breeding lines (Table 1) for evaluation under PNG environments and assisted the project in developing and implementing a technical work plan for the varietal trials. It is expected that some of the promising varieties will be eventually released for cultivation by smallholders in PNG. However, it is important that genetic purity and viability of the germplasm is

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

Table 1. List of groundnut varieties supplied by ICRISAT to Papua New Guinea during 2001–2002

Serial no.	Short-duration genotypes	Serial no.	Medium-duration genotypes
1	ICGV 94299	21	ICGV 92029
2	ICGV 94341	22	ICGV 94016
3	ICGV 94350	23	ICGV 94037
4	ICGV 94357	24	ICGV 94040
5	ICGV 94358	25	ICGV 92160
6	ICGV 94361	26	ICGV 93058
7	ICGV 95244	27	ICGV 93115
8	ICGV 95245	28	ICGV 93123
9	ICGV 95248	29	ICGV 93139
10	ICGV 95271	30	ICGV 93143
11	ICGV 95278	31	ICGV 94043
12	ICGV 95290	32	ICGV 94049
13	ICGV 95299	33	ICGV 94113
14	ICGV 95319	34	ICGV 94215
15	ICGV 95322	35	ICGV 95163
16	ICGV 95256	36	ICGV 95165
17	ICGV 96468	37	ICGV 95172
18	ICGV 96469	38	ICGV 95179
19	ICGV 96470	39	ICGV 96066
20	ICGV 96466	40	ICGV 96073
		41	ICGV 96081
		42	ICGV 96100
		43	ICGV 96107
		44	ICGV 96108
		45	ICGV 96110
		46	ICGV 96234

maintained as a separate exercise by the PNG agricultural R&D agencies.

In this paper, we have attempted to explain the various aspects of purity and viability of peanut germplasm seeds and protocols to maintain them. The concern for genetic purity and viability is of paramount importance in genebank operations and appropriate procedures need to be outlined (Rao and Bramel 2000).

Germplasm purity can be identified at two levels: physical purity and genetic purity.

Physical purity

Germplasm accessions should be free from seeds of other crops, weeds, plant debris or soil. This can be ensured easily with good crop management, and pre- and post-harvest care.

Genetic purity

Genetic purity means that the germplasm accessions should be maintained in close to the same structure (genetic composition/entities) as they were originally secured from the source. Maintaining such structure will also need attention in subsequent germplasm handling, namely at the time of regeneration, characterisation, labeling, seed cleaning and processing.

Protocol for maintaining genetic purity in peanut germplasm

Peanut descriptors

A set of traits that are important for diagnostic purposes, agronomic characterisation and grain nutritional value are recognised and known as 'descriptors' of the crop species. The 'peanut descriptors' (IBPGR and ICRISAT 1992) were developed jointly by ICRISAT and International Plant Genetic Resources Institute (IPGRI) researchers together with other internationally known scientists. Each peanut germplasm accession in the ICRISAT genebank has been characterised for these traits and data are maintained on the ICRISAT website (www.icrisat.org) for the benefit of users. Some diagnostic traits of peanut that could be used for verifying genetic purity of germplasm accessions are given below:

Growth habit Plant growth patterns can be grouped into the following seven classes: procumbent-1, procumbent-2, decumbent-1, decumbent-2, procumbent-3, erect and other (Figure 1), which are recorded at the pod-setting stage.

Plant height (cm) The height of the main axis is measured on 10 representative plants from ground until terminal bud at 60–85 days after emergence.

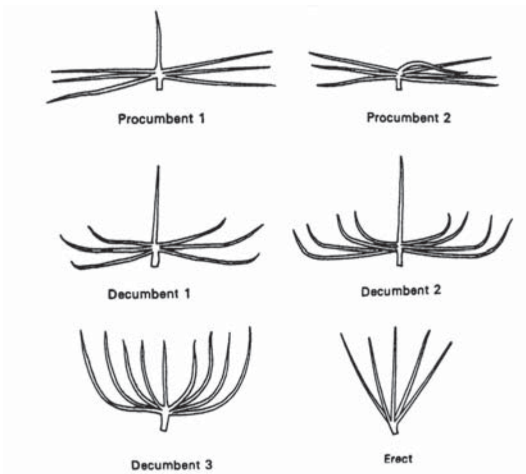

Figure 1. Growth habit classes in peanut germplasm (Source: Rao and Bramel 2000)

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

Stem pigmentation Presence of anthocyanin pigmentation on the stem is recorded at flowering stage as either present or absent.

Stem hairiness Hairiness on the main stem of peanut germplasm is recorded at flowering stage as one of the following five classes: (i) glabrous (no hairs); (ii) sub-glabrous (hairs in one or two rows along main stem); (iii) moderately hairy (three or four rows along the main axis); (iv) very hairy (most of the stem surface covered with hairs); and (v) woolly (most of the stem surface covered with long hairs).

Branching pattern The pattern of branching is recorded in the following five classes: (i) alternate, (ii) sequential, (iii) irregular with flowers on main stem, (iv) irregular without flowers on main stem and (v) others (Figure 2).

Leaflet length (cm) The length of the apical leaflet of the fully expanded third leaf on the main stem is recorded on 10 leaflets from different plants.

Leaflet width (cm) The width of the apical leaflet of the fully expanded third leaf on the main stem is recorded at its widest portion on 10 leaflets from different plants.

Leaflet shape The shape of fully expanded apical leaflet of the third leaf on the main stem is recorded in 14 classes (Figure 3).

Days to 50% flowering Number of days from emergence to the day on which 50% plants of an accession have flowered.

Flower colour Seven flower colours could be identified in peanut. The colour of the front face of the vexillum excluding the streak portion of the fresh and fully opened flowers is recorded. The seven colours are: white, lemon, yellow, orange-yellow, orange, dark orange and garnet/brick red.

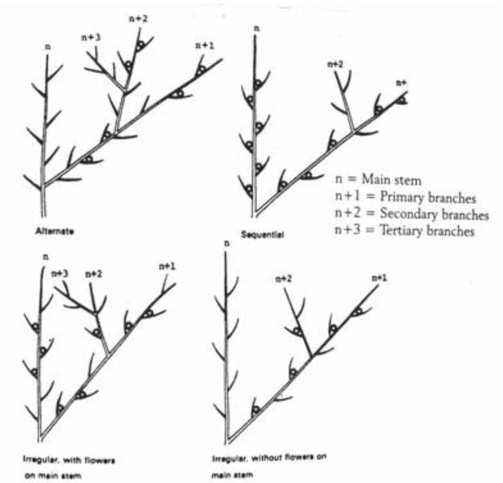

Figure 2. Branching pattern classes in peanut germplasm (Source: Rao and Bramel 2000).

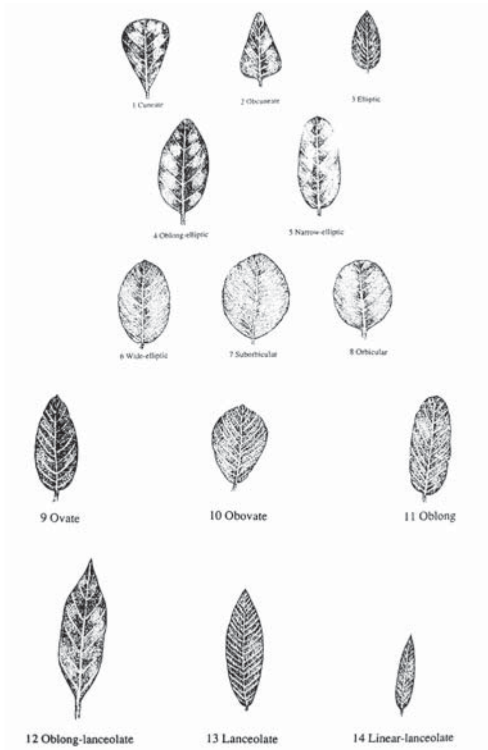

Figure 3. Leaflet shape classes in peanut germplasm (Source: Rao and Bramel 2000)

Pod beak Pod beak (i.e. tip of the indehiscent pod) is recorded in five classes: absent, slight, moderate, prominent and very prominent (Figure 4).

Pod constriction The degree of pod constriction is recorded in five classes: no constriction, slight, moderate, deep, and very deep constriction (Figure 5).

Pod reticulation Also known as pod venation, this characteristic is recorded in five classes: no reticulation, slight, moderate, prominent, and very prominent.

Pod length (cm) This is the average of 10 representative mature pods.

Pod width (cm) This is the average of 10 representative mature pods.

Seed number per pod The pattern of seed number in pods is an important diagnostic and agronomic trait. The number can vary from 1–4, rarely 5 (Table 2). The first number indicates most frequent number of seeds in pods of an accession, the second indicates second most frequent number and so on.

Primary seed colour This should be recorded within 1 month of harvest on dry and mature seeds. Twenty primary seed colors can be found in peanut germplasm accessions (Table 3).

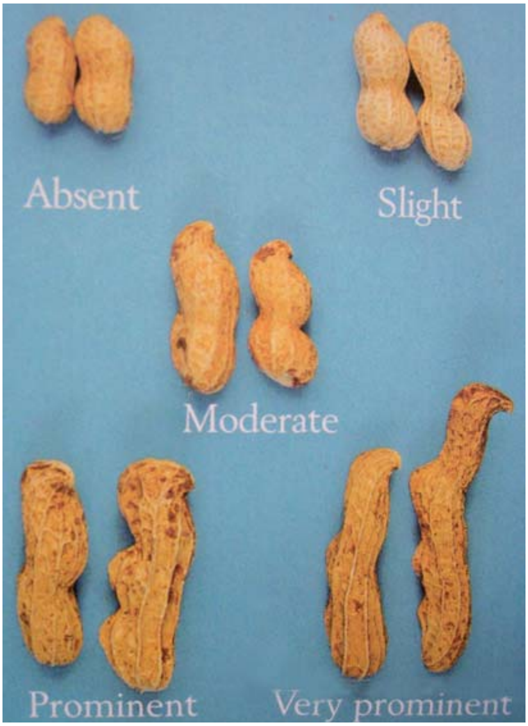

Figure 4. Pod beak classes in peanut germplasm (Source: Nigam et al. 2004)

Table 2. Commonly found seed numbers per pod in groundnut germplasm

1.	2-1
2.	2-3-1/2-1-3
3.	3-2-1/3-1-2
4.	2-3-4-1/2-4-3-1/2-3-1-4/2-4-1-3/2-1-3-4/2/1/4/3
5.	3-2-4-1/3-2-1-4
6.	3-4-2-1/3-4-1-2
7.	4-3-2-1/4-2-3-1
8.	4-3-1-2/4-2-1-3
9.	3- or 4-seeded with occasional 5-seeded pods

Table 3. Major colours found on peanut germplasm seeds

1	White	8	Dark tan	15	Light purple
2	Off-white	9	Greyed orange	16	Purple
3	Yellow	10	Rose	17	Purple
4	Very pale tan	11	Salmon	18	Dark purple
5	Pale tan	12	Light red	19	Very dark purple
6	Light tan	13	Dark red	20	Other
7	Tan	14	Purplish red		

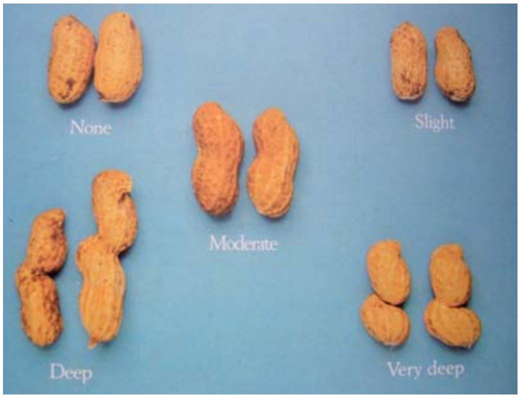

Figure 5. Pod constriction classes in peanut germplasm (Source: Nigam et al. 2004)

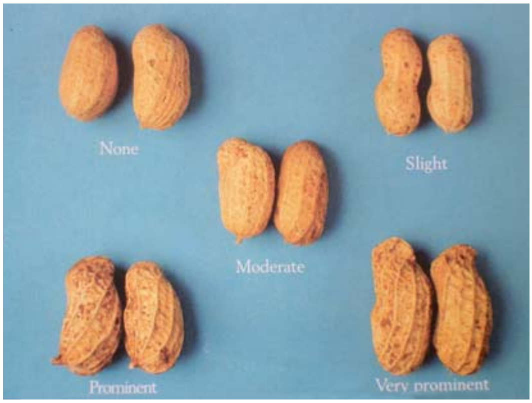

Figure 6. Pod reticulation classes in peanut germplasm (Source: Nigam et al. 2004)

Protocols for peanut germplasm regeneration to ensure optimum genetic makeup and healthy seeds

Sowing

To ensure optimum genetic structure of the accessions, a minimum of about 160 plants per accession are grown for regeneration. A plant-to-plant spacing of 60 × 10 cm will be adequate for the accessions of subsp. *fastigiata* and 60 × 15 cm for subsp. *hypogaea* so that each plant could be examined conveniently. Seeds of subsp. *hypogaea* should be treated with Ethrel® (2-chloroethylphosphonic acid, 39%) solution (3 mL L^{-1}) to break seed dormancy and ensure

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

even germination. The field selected for regeneration should be well drained with light textured soil and a good calcium status. The field should have a minimum gap of 2 seasons between two peanut crops. This is to overcome the problem of peanut volunteers from the previous crop and also to avoid disease and insect buildup in the soils. The crop could be provided with 60 kg P_2O_5 ha^{-1} as basal fertiliser, and 60 kg calcium (400 kg gypsum) ha^{-1} at 40 days after sowing.

Cultural practices

To ensure adequate seed yield, the crop should be kept weed, insect and disease free. The crop should be maintained with adequate soil moisture to produce healthy seeds by irrigating the field when necessary. The crop should be inspected at various stages to verify the genetic identity and health of the accessions and rogue out the doubtful/ diseased plants.

Harvesting

Determining the right harvesting time in peanut is crucial. As an indeterminate plant, peanut can produce flowers until maturity. This behaviour results in fruits being at different stages of development, making it difficult to decide the harvesting date. To judge maturity, various parameters have been designed, such as optical density of oil (Sharon 1963; Young and Holley 1965), arginine maturity index (Hammons et al. 1978), methanol extract (Holiday et al. 1976, 1979; Pearsson et al. 1973), kernel density (Aristizabal et al. 1969), internal pericarp colour (Gilman and Smith 1977), seed hull maturity index (Pattee et al. 1974), maturity protein marker (Basha 1990), cumulative thermal time (Leong and Ong 1983; Mohamed 1984; Williams et al. 1975). These parameters are too technical and not easy to practise. Each one of them has some shortcomings. In simple words, however, optimum harvesting time is indicated by (i) when about 75% pods have matured, (ii) leaves start yellowing and old leaves start shedding, (iii) pods becoming hard and tough with dark tannin coloration inside shell, (iv) kernel surface becoming smooth and (v) testa developing seed colour characteristics of the genotype.

Harvesting is done by uprooting the plants and picking the pods manually. Pods of Spanish, Valencia, and Virginia Bunch types are confined to the base of plant and pulling plants from soil brings out most of the pods. In the Virginia-runner type, however, pod formation takes place all along the creeping branches. Therefore, plants are pulled out with the help of shovel or spade.

If soil is hard, lightly irrigate the crop 1 day before harvesting.

Leave the uprooted plants in the field with pods turned up for 1–2 days for drying and then pluck the pods.

When the day temperature reaches higher than 40°C during harvesting, dry the uprooted plants under shade or pick the pods immediately. If the highly moist, fresh pods (30–40% moisture) are exposed to strong sunlight (temperature >40°C) even for 1 day, the seed viability is affected.

After drying the pods in shade for 3–4 weeks, shell them manually, process, and pack the seeds for conservation.

Protocols for efficient germplasm seed conservation

Conserving germplasm as seed in contrast to pods is convenient, scientific, and cost effective. The gain in seed longevity is very marginal while conserving peanut in-shell. In the medium-term conservation (MTC) facility, germplasm conservation as seed was about three times more cost effective than as peanut-in-shell (Rao et al. 2000). This is primarily due to the larger space occupied by peanut-in-shell.

After shelling, let the seeds dry in shade or in a controlled environment to moisture content about 7% for MTC (4°C, 30% RH) and 3–5% for long-term conservation (LTC) (-20°C).

It is desirable to pack the seeds in air-tight, screwed lid containers for MTC (active collection) and in non-permeable, vacuum sealed containers for LTC to ensure longer viability.

Ensuring optimum viability of the germplasm seed is important. Viability refers to the ability of seed to germinate and produce a healthy plant. Before the germplasm is taken to LTC, seed germination is recorded. Depending on the initial germination per cent, plans are made for subsequent germination tests. For active collection, tests are made after 8 years on the accessions that had >95% germination at initial stage, after 5 years on accessions having 85–95% germination and after 3 years on accessions that had <85% germination. For base collection, viability should be monitored after 10 years on accessions that had >95% at the initial stage, after 8 years on accessions having 85–95% germination and after 5 years on accessions that had <85% germination. Seeds are also examined for the seed associated micro-organisms and assessment is made for possible damage. If the damage is conspicuous, seeds will be treated with an appropriate chemical before the next regeneration to ensure production of healthy seeds.

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

Protocol for handling wild *Arachis* germplasm

Wild *Arachis* spp. require additional care to maintain their germplasm resources. Some of the species require longer duration to set seeds, and some produce very few, small sized, and distantly placed pods. Some species do not set pods and seeds and are maintained vegetatively. Wild *Arachis* species are better maintained in controlled environmental facilities, namely in glasshouse where plants are maintained year round. Alternatively, plants are raised in pots placed in isolated and protected area. The following are some guidelines to maintain the wild *Arachis* germplasm.

Use big size earthen or plastic pots (40 × 30 cm) or concrete rings (65 × 85 cm). Cover the hole at the bottom of the pot with pieces of rubble. Fill the container with pasteurised soil mixture containing three parts red soil, two parts sand and one part farmyard manure. Seeds should be dressed with appropriate fungicide and sown at a depth of 3–4 cm. Many of the wild *Arachis* species have seed dormancy so 2–3 drops of Ethrel® (3 mL L^{-1}) should be applied to seeds before they are covered with soil. Take care to ensure adequate soil moisture in pots and apply gypsum at 10 g per pot 50 days after sowing.

Maintenance of species that are vegetatively propagated

- Use a 20 cm long rhizome cut from the mother plant.
- Soak the rhizomes in Bavistin® suspension (3 g L^{-1}) for 5 minutes.
- Plant the rhizomes in a potting mixture consisting of three parts red soil, two parts sand and one part farmyard manure.
- Plant the rhizomes 5 cm deep, preferably in plastic or earthen pots.
- Maintain the rhizomes in a glasshouse at 25 ± 2°C until they are established.
- It helps to maintain the rhizomes under alternating dry and wet conditions until they are established.
- Rhizomes require 1 month for establishment after which they can be transferred to the field.

Conclusion

Present and future crop improvement programs require genetically pure and healthy germplasm material. Pure and healthy germplasm in genebanks provides the genetic bricks for research by the future generations. Therefore, all possible care should be taken for maintaining pure and healthy seeds in the genebanks.

References

Aristizabal L., Burns E.E. and Kunze O.R. 1969. Physical, chemical and organoleptic properties of peanut separated in a controlled air stream. Transactions of American Society of Agricultural Engineers. 12(3), 298–301.

Basha S.M. 1990. Protein as indicator of peanut seed maturity. Journal of Agricultural and Food Chemistry 38: 373-376.

FAO 2002–04. Food and Agriculture Organization of the United Nations. Website www.fao.org

Gilman D.F. and Smith O.D. 1977. Internal pericarp color as a subjective maturity index for peanut breeding. Peanut Science 4, 67–70.

Hammons R.O., Tai P.Y.P. and Young C.T. 1978. Arginine maturity index: Relationship with other traits in peanuts. Peanut Science 5, 68–71.

Holiday C.E., Williams E.J. and Chew V. 1976. An evaluation of two objective methods for estimating maturity in peanut. (Abstr.) Proceedings of the American Peanut Research and Education Association 8, 78.

—1979. A methods for estimating peanut maturity. Journal of Food Science 44, 254–256.

IBPGR and ICRISAT 1992. Descriptors for groundnut. International Board for Plant Genetic Resources, Rome, Italy; International Crops Research Institute for the Semi-Arid Tropics, Patancheru, India.

Leong S.K. and Ong C.K. 1983. The influence of temperature and soil water deficit on the development and morphology of groundnut. Journal of Experimental Botany 34, 1551–1561.

Mohamed H.A. 1984. Varietal difference in the temperature responses of germination and crop establishment. PhD Thesis, University of Nottingham, UK.

Nigam S.N., Giri D.Y. and Reddy A.G.S. 2004. Groundnut seed production manual. Patancheru 502324, AP, India: International Crops Research Institute for the Semi-Arid Tropics. pp 28.

Pattee H.E., Johns E.B., Singleton J.A. and Sanders T.H. 1974. Composition changes of peanut fruit parts during maturation. Peanut Science 1, 57–62.

Pearson J.L., Holiday C.E., Butler J.L., Williams E.J. and Troeger J.M. 1973. Objective determination of optimum harvest maturity (Abstract). Proceedings of the American Peanut Research and Education Association 5, 197.

Rao N.K. and Bramel P.J. 2000. Manual of genebank operations and procedures. ICRISAT, Technical Manual no 6. pp 190.

Sharon H.D. 1963. Measurement of peanut quality and factors influencing it. Peanut Improvement Working Group Proceedings, Oklahoma State University, pp. 1–15.

Williams J.H., Wilson J.H.H. and Bates G.C. 1975. The growth of groundnut (*Arachis hypogaea* cv. Makulu) at three altitudes in Rhodesia. Rhodesian Journal of Agricultural Research 13, 33–43.

Young C.T. and Holley K.T. 1965. Comparison of peanut varieties in storage and roasting. Georgia Agricultural Experiment Station Technical Bulletin No. 41, p. 30.

'Smartpeanut' — a suite of software tools that apply economic analysis to peanut farming systems in Australia

F. Chudleigh, M.J. Bell, Rao C.N. Rachaputi, Y.S. Chauhan and G.C. Wright

Department of Primary Industries and Fisheries, PO Box 23, Kingaroy, Queensland 4610, Australia; email: rao.rachaputi.dpi.qld.gov.au

Abstract

'Smartpeanut' is a suite of software tools that combines an economic framework and crop simulation models to analyse farming systems as an investment. The tool can also assist in assessing other physical resource impacts such as soil loss, drainage, run-off and nitrate depletion. While 'smartpeanut' does not provide optimal solutions to problems, it can assist consultants and growers in the decision making process by presenting a range of relevant economic scenarios associated with peanut farming systems. Examples include comparing economic risks and opportunities of various crop rotations, investments in new farm machinery, options to improve economic viability of the enterprise in relation to resources such as farm size, leasing versus owning land/machinery etc. 'Smartpeanut' will also be useful as a research tool for farming systems researchers as it can enable study of the impacts of climate and agronomic practices on farm sustainability and profits. The databases of several peanut growing regions in Australia have been compiled and included in the 'smartpeanut' CD for evaluation by consultants and growers.

Introduction

Discussions at several peanut grower group meetings in Queensland have revealed a need for a decision support package to assist peanut growers with a capacity to explore opportunities and economic risks based on both in-season crop risk monitoring as well as long-term scenario analysis.

A workshop with peanut industry participants and researchers held in December 2002 at Kingaroy led to identification of specific decision support needs of industry participants. Defined needs included the following:

- A capacity to assess a wide range of decisions from paddock to farm scale. These decisions include the assessment of production and financial risks, together with many aspects of the financial and economic management of peanut farming systems, up to and including investment analysis.
- An ability to include the production and financial structure of an individual farm business within the decision support framework.
- Outputs to be provided in financial, economic and production terms understood by industry participants.
- A capacity to include research results into peanut production systems as the research is completed.

It was clear from the discussions that a suite of tools was needed to undertake the range of production, economic and financial analyses required by the meeting participants.

It became one of the objectives of the ASEM 2001/055 project to develop a software package which would address the above listed needs of the Australian peanut industry.

Material and methods

The development of the software package required a combination of farm economics and crop modelling skills and involved the following steps:

- Assembling databases of soil, crop, weather, farm machinery and a range of cost inputs typical of (small, medium and large) peanut farm holdings
- Customising elements of currently available farm economics models to suit Australian peanut farming systems
- Generating outputs from complex biophysical models using the above crop and climate databases for typical farm holdings
- Combining farm economic models with outputs from biophysical models to develop an interactive farm financial package ('smartpeanut')

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

- Evaluating the performance of 'smartpeanut' with selected growers, and ultimately with the entire peanut industry.

The software package developed was a decision support tool at the whole farm level. The 'smartpeanut' package, including a database of costs associated with the peanut industry, can be used to generate a set of parameters with the financial and production characteristics of many typical peanut farming businesses, and can be linked to simulated yields for peanut cropping systems. This tool mainly looks at the long-term impacts of peanut industry investments on economic, financial, production and sustainability indicators. Other simpler tools that assess a range of farm enterprise investments, for example, machinery purchase or replacement, costs of alternative peanut drying systems, are also included in the package.

Results

'Smartpeanut' software package

The total package consists of a large number of separate spreadsheets and documents dealing with many aspects of farm management and peanut production systems. A number of case-study type spreadsheets for peanut farming systems in Southeast and North Queensland are also included.

The existing spreadsheets and documents have been compiled onto a CD ready for installation. Once installed, the first screen of the CD acknowledges the support given by various funding bodies and uses an interactive menu approach (Figure 1).

Spreadsheets and documents are all copied from the CD onto the user's computer for ease of evaluation and use. An icon is placed on the desktop of the user's computer to allow access to a contents menu (Figure 2).

The core components of the 'smartpeanut' package are the 'smartpeanut' and 'Development smartpeanut' spreadsheets.

The 'smartpeanut' and 'Development smartpeanut' spreadsheets can both be linked to databases of location specific cropping system simulations. Included within the 'smartpeanut' package are pre-run databases and cropping systems descriptors relevant to cropping systems located in southern, central and northern Queensland.

The 'smartpeanut' spreadsheet is a complex tool for the analysis of integrated cropping systems at the level of the whole farm. The outputs include estimates of cash flow, farm returns, gross margin, drainage, run-off, soil loss and resource use on a crop, seasonal, annual or decadal basis over discrete periods of the available climate data for any location. The 'smartpeanut' spreadsheet has the capacity to compare production systems that have two separate crop rotations with up to five separate summer or winter crops within each rotation. Each crop rotation can also have two discrete planting windows.

The 'Development smartpeanut' spreadsheet is equally as complex as smartpeanut, except it is aimed at analysing partial investment decisions, normally at the paddock level. For example, this spreadsheet could be used to consider the impact of investing in capital equipment to convert a dryland-cropping paddock to an irrigated-cropping paddock. The 'Development smartpeanut' spreadsheet can access the same database of cropping system runs as the 'smartpeanut' package.

Using the spreadsheet tools

The 'smartpeanut' spreadsheet tool provides peanut industry participants with a structure for undertaking detailed investigations into the long-term variability

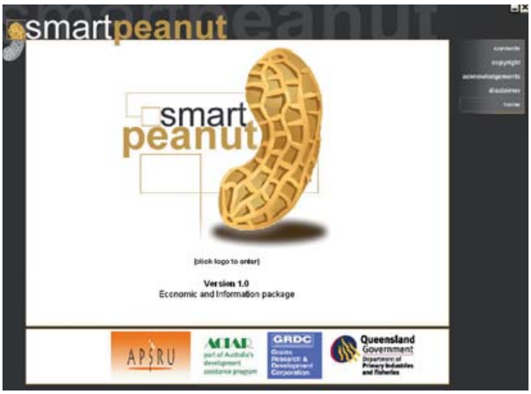

Figure 1. First screen seen on the 'smartpeanut' package

Figure 2. Contents screen seen on the 'smartpeanut' package

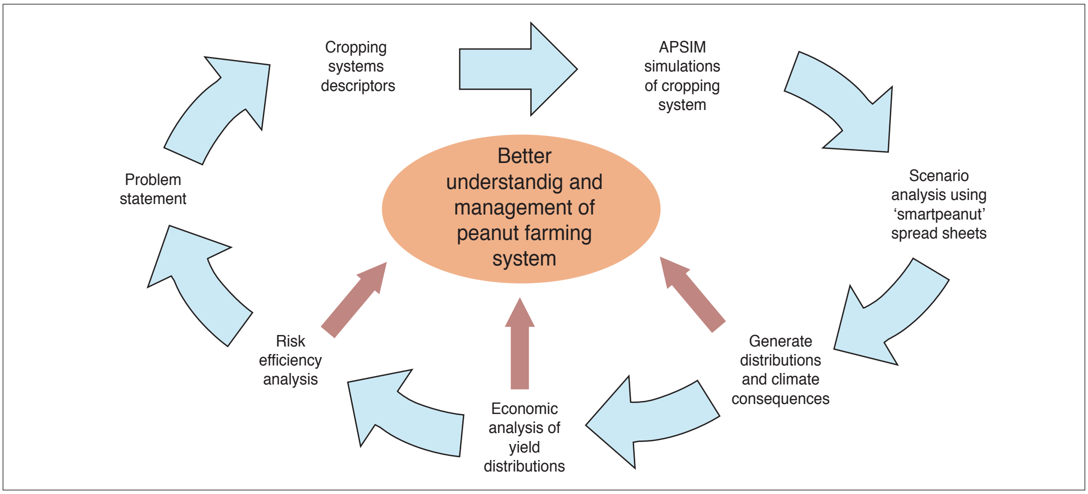

Figure 3. Steps in the analysis of a peanut production system using the 'smartpeanut' process

and riskiness of peanut production systems as well as investigations into the short-term responses likely to a change in the production strategy applied at the paddock level. Outputs from the model for financial, economic and sustainability parameters can be considered as either probabilistic distributions of outcomes or as scenarios based on discrete climate sequences.

Industry participants undertaking an analysis of peanut production systems using 'smartpeanut' must firstly identify the issue of concern as a concise problem statement (Figure 3). Usually, there are two sides to the problem of concern. Either the peanut production system can continue as is (the 'without change' scenario) or it can be changed to an alternative production system (the 'with change' scenario). The economic outcomes of a 'smartpeanut' spreadsheet analysis always rely on this central comparison of continuing with the current system or changing to an alternative one.

Once the issue of concern has been identified and the alternative production systems have been precisely described, the biophysical components are modelled in APSIM (McCown et al. 1995). Simulation modelling using tools like APSIM has allowed researchers to explore the biophysical risks associated with climate variability in production systems in different regions (e.g. how often in the climate of the last 50–100 years would investing in irrigation equipment have provided peanut yield advantages).

When the inherent riskiness of a variable climate (generated by APSIM) is combined with input costs, price volatility and added to the farm size, machinery and other farm overheads using the 'smartpeanut' spreadsheet model, an assessment of the financial risk associated with various farm management options can be made. When this information is tailored to a particular farming enterprise, operators or advisors can then assess strategies for improving farm viability (e.g. purchasing or leasing land, investing in irrigation etc.). The outputs from the economic analysis described above will be directly relevant to the better understanding and management of the whole farm (Figure 3).

Example outputs for 'smartpeanut' spreadsheet

The information provided by combining climate data and the systems modelling capability of APSIM can be quite powerful. Figures 4–6 present outputs generated by the 'smartpeanut' spreadsheet for a conventional 300 ha peanut cropping property at Kingaroy, Queensland, Australia and examine the relative levels of performance of this farm business over time. The rotation followed on the property is a peanuts–fallow–maize–fallow system without winter crops.

Figure 4 provides a comparison of the stability of yield and gross margins from early maturing ('quick') and late maturing ('slow') peanut cultivars sown in two (i.e. early and optimum) planting windows. The outputs show that planting opportunities for the early planting window have, at times, been much less frequent than growers' current expectations.

Another way of summarising the variation in annual yields, as shown in Figure 4, is to compile the data into probability of exceeding certain yields (Figure 5). This suggests that there was a 60% chance of harvesting some pod yield from an early (16 Oct – 15 Nov) sowing

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

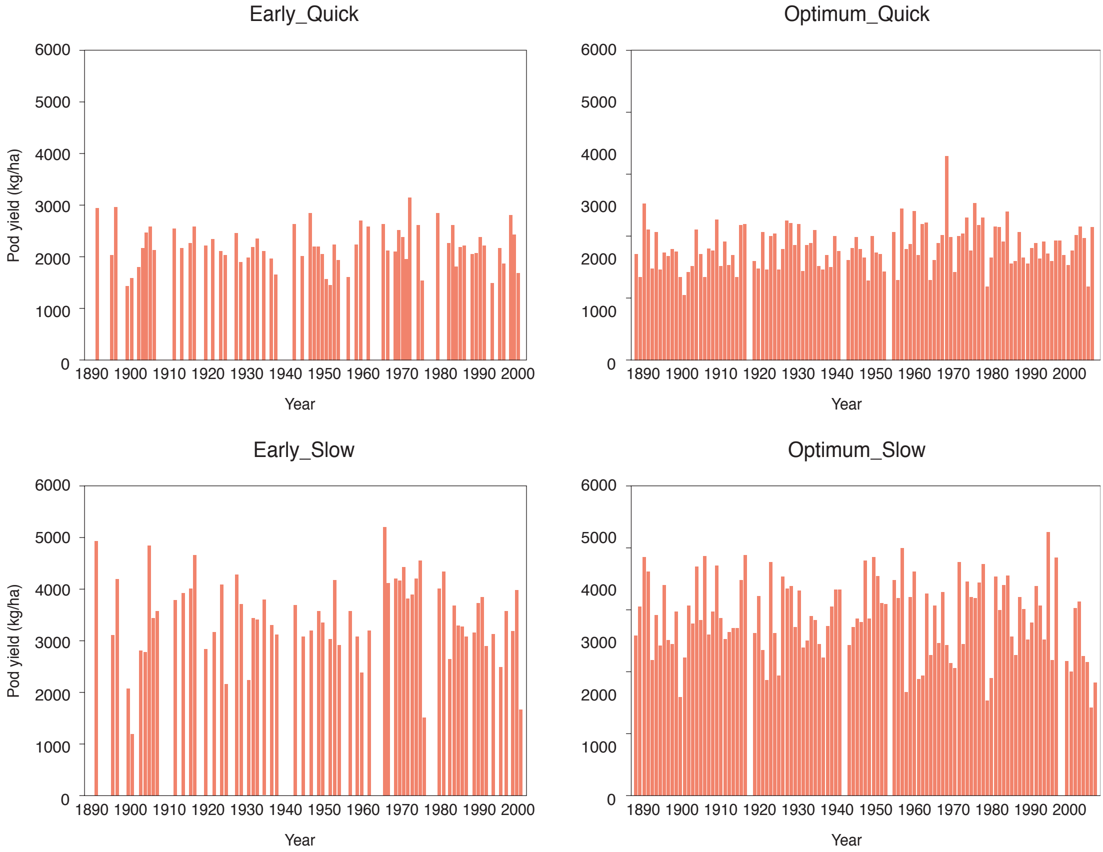

Figure 4. Frequency and extent of modelled peanut crop yields for early-maturing (quick) and later-maturing (slow) cultivars in early (15 Oct – 10 Nov) and optimum planting windows (16 Nov – 15 Jan) at Kingaroy, Queensland, Australia between 1890 and 2003

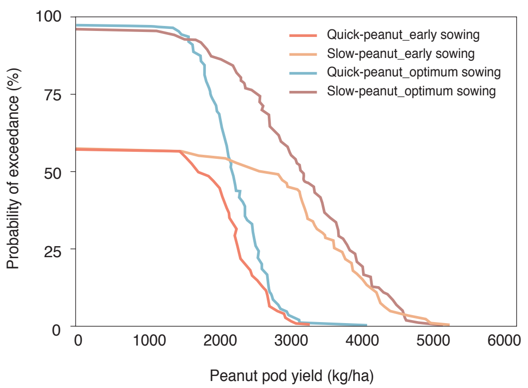

Figure 5. Probability of simulated pod yields of 'quick' and 'slow' peanut cultivars in different cropping windows at Kingaroy, Queensland, Australia

window, whereas there was a nearly 95% chance of obtaining some pod yield from the optimum-sowing (after 16 November) window. Understandably, pod yields from early maturing ('quick') peanut cultivars were lower than late maturing ('slow') peanut cultivars due to differences in growing period. However, a better indication of climate variability contributing to yield variation is provided by plots of 10-year moving averages in peanut pod yield and gross margins (Figure 6). These figures suggest that 'slow' peanut cultivars in the optimum sowing window consistently produced higher pod yields and generated larger gross margins.

However, the profitability of 'slow' peanut cultivars sown in the early sowing window seemed to improve in the climatic sequence since 1970, relative to earlier in the century. This improved profitability of early-sown crops has been consistent with growers'

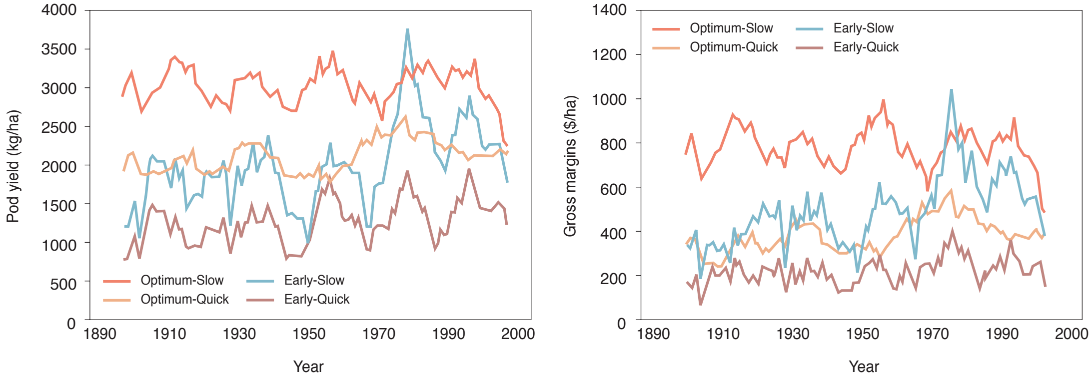

Figure 6. Decadal moving averages of simulated pod yield and annual gross margins of quick and slow peanut cultivars in early and optimum sowings at Kingaroy, Queensland, Australia between 1890 and 2003

perceptions of early sowing as a risk mitigation strategy. The experiences of today's growers may have been different if they had begun farming in 1910 rather than 1970!

Despite being somewhat more consistent in producing yields, the 'quick' peanut cultivars are unable to compensate for the lower yields in better seasons and consistently produce lower gross margins. The least profitable of any sequence were 'quick' cultivars sown in the early sowing window.

Another inference that can be drawn from these plots of moving averages is that there were continuous declines or increases in yield and gross margins for extended periods (a decade or so). For example, a grower who bought a property in 1965 would have substantially benefited from early planting of 'slow' peanut cultivars whereas the grower who bought property in 1995 would have seen declining yields and profits (Figure 7). However, if a grower had used a 'quick' peanut cultivar in the optimum sowing window, then profits would have fluctuated less wildly, although they would have been smaller than from a 'slow' peanut cultivar.

APSIM has a capacity to reconcile the relationships between the production system modelled and the resource base. Changes in indicators such as soil loss, drainage, run-off, evaporation, and ground cover can all be output for any cropping system. Annual soil loss estimates for a conventional peanut cropping system are shown in Figure 8.

An economic analysis of dryland peanut farming systems in Queensland showed that farms are under increasing pressure to remain viable. Climate variability at any location has a major impact on the 'riskiness' of

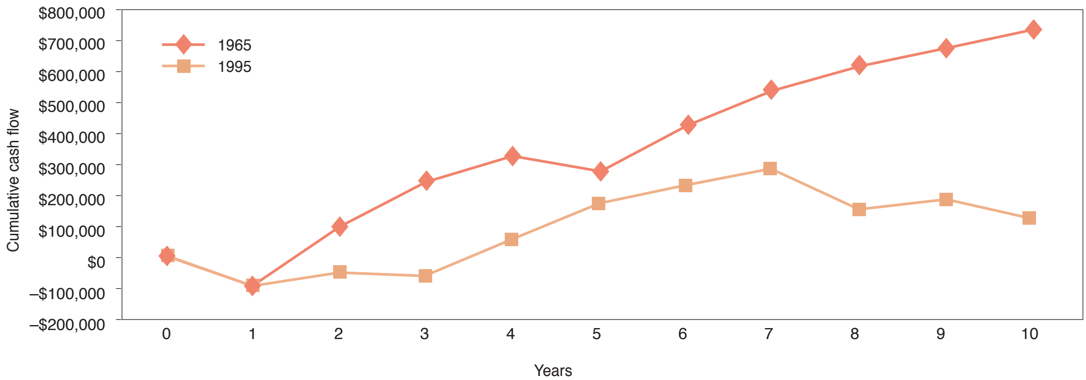

Figure 7. Modelled cash flows for a 300 ha peanut and maize cropping farm at Kingaroy, Queensland, Australia that begins with no debt in either 1965 or 1995 and experiences the climate of the next decade. Prices of inputs and produce were held constant.

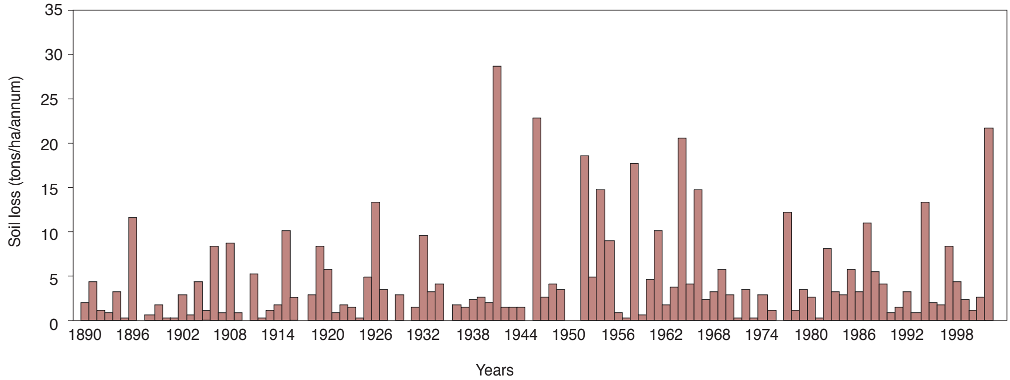

Figure 8. Predicted annual soil loss for a conventional peanut and maize farming system at Kingaroy, Queensland, Australia from 1890 to 2004

operations. Simulation models can clearly aid in assessing these risks. Preliminary analyses show machinery and equipment ownership costs are a major threat to viability.

What do we do with the information generated by 'smartpeanut'?

'Smartpeanut' can be used to generate information to predict economic performance of the whole farm under various management scenarios. The information generated by the program can be used in a number of ways. The combinations of production risk, variation in commodity prices, varying farming systems and differing fixed cost structures enabled us to examine the long-term viability of typical management decisions. An example might be a comparative assessment of various crop rotations and their effects on cumulative cash flows over a 20-year period. Obviously any such comparison can only be in general terms, because there is no guarantee that future climate (and associated risk) will resemble the past. In order to make such analyses more relevant to individual producers, details such as farm structures, borrowings and machinery overheads can be individualised for a particular farming operation, so the potential benefits (or otherwise) of particular management decisions on the viability of that farm enterprise could be assessed. We see the development of these tools as a major step for farmers and advisers to minimise the risks associated with farm management decisions.

Conclusion

The complex economic modelling and analysis tools of the 'smartpeanut' program provide economic insights into the nature of peanut farming systems. The results of using these tools can be incorporated into whole farm steady state or gross margin budget structures also found on the 'smartpeanut' CD for extension to the peanut industry. In this way 'smartpeanut' incorporates both a problem solving tool box for business managers and a research tool for farming systems researchers.

References

McCown R.L., Hammer G.L., Hargreaves J.N.G., Holzworth D.P. and Freebairn D.M. 1995. APSIM: A novel software system for model development, model testing, and simulation in agricultural systems research. Agricultural Systems 50, 255–271.

Progress report on a peanut market study in Papua New Guinea

Norah Omot[1], Trevor Wilson[2], Jesse Anzen[1], A. Ramakrishna[3], Yanding Tomda[3] and Timothy Geob[3]

[1]*National Agricultural Research Institute, PO Box 4415, Lae, Papua New Guinea; email: norah.omot@nari.org.pg*

[2]*Department of Primary Industries and Fisheries, Brisbane, Queensland 4610, Australia*

[3]*National Agricultural Research Institute, PO Box 210, Aiyura, Eastern Highlands Province, Papua New Guinea*

Abstract

Peanut is an important cash crop for many rural growers and urban vendors in Papua New Guinea (PNG) and is sold as snack food in various forms (fresh, dried, fried, roasted or boiled). The ACIAR peanut research project may lead to improved productivity, quality and production. However, the extent to which increased production will be absorbed by the domestic market is not known. Also, increased supply may not necessarily create an increased market demand for the peanuts. A market study was therefore initiated to understand current relationships between demand, supply and price of peanuts in the PNG domestic market, and assess the reaction of peanut growers and consumers to possible future changes in demand for and price of peanut. The average price of peanuts at the Port Moresby and Lae markets is K8/kg and K5/kg, respectively. Preliminary analysis of data collected from urban peanut consumers at the Port Moresby and Lae markets indicates that most consumers would increase their purchase by about 160% if prices were halved. On the other hand, if prices doubled, consumers would reduce peanut purchases by about 41%. The final report of the market study (in preparation) will provide estimates of volume traded in the PNG domestic market, as well as estimates of current and potential demand for fresh or processed peanuts, and other peanut products such as peanut butter.

Introduction

Peanut has been identified as an important cash crop for many rural people as well as for many settlers in the urban areas of Papua New Guinea (PNG). It is estimated that more than 12,600 tonnes of peanut are grown every year (Wemin and Geob 2004). In some regions, peanut production and trade have increased over the last 18 months, especially in the Markham Valley, due to rapid decline in the yield of betel nut, which is the major source of cash income for farmers there.

While crop improvement research offers opportunities to increase productivity and quality, it is necessary to assess the impact of increased productivity (supply) on domestic market demand and price as well as consumer sensitivities to possible future changes in supply of and demand for peanuts in the market. The information will be also useful for exploring new market opportunities for peanuts and peanut products in PNG.

A survey of peanut farmers conducted as part of the ASEM 2001/055 project established the importance of peanut in the four major peanut growing areas (Eastern Highlands, Morobe and East New Britain provinces and the National Capital District) and described the status of peanut production and variation in market prices in the surveyed regions. However, there is a need to generate information about the volumes of peanut traded in various markets and to assess consumer sensitivity to possible changes in production and price of peanut. As a part of the extension phase of the project, a survey was undertaken at selected markets in Central, Morobe, Madang, Eastern Highlands and Western Highlands provinces to assess consumer preferences and market demand for various peanut products, as well as

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

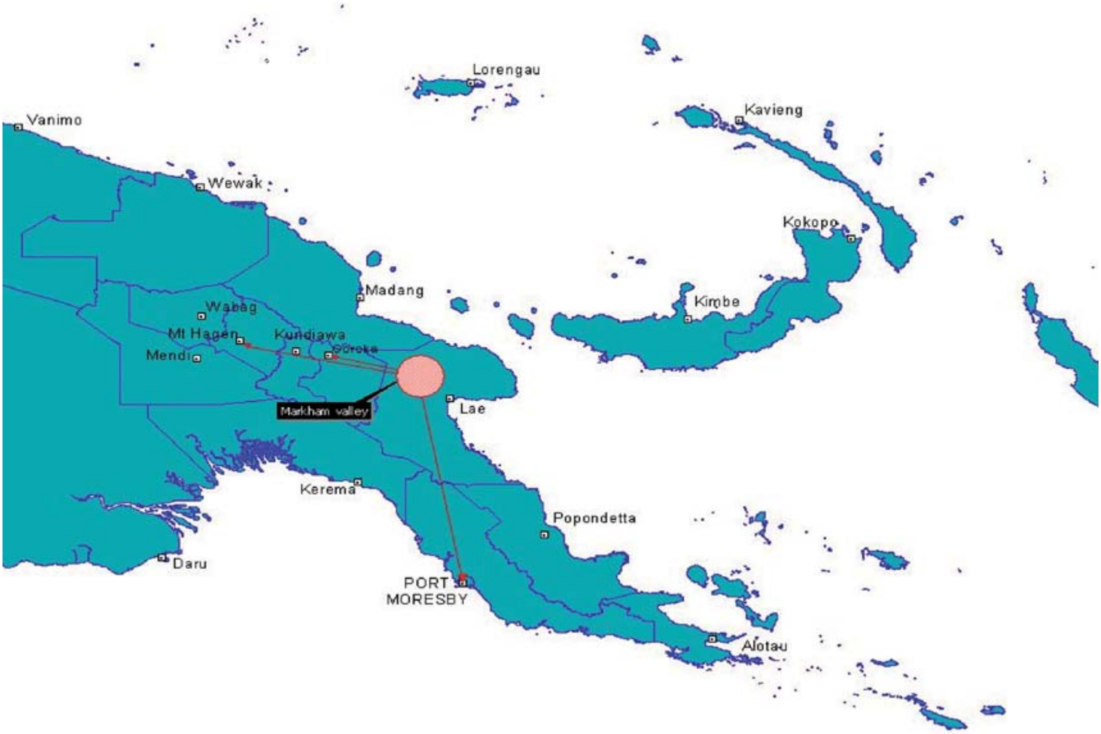

Figure 1. Movement of peanut from the Markham Valley, Papua New Guinea (circle) to Lae and other provinces

movement of peanut within the country. In addition to the analyses of demand and supply and price scenarios, the market study will also provide estimates of volume traded in the PNG domestic market and potential demand for peanuts and peanut products in PNG markets.

Methodology

The target populations in the survey consisted of consumers (184), middlemen (56) and growers (54). People were interviewed in 5 provinces and at a total of 7 markets. Separate questionnaires were used for the different populations. This progress report presents the results from the Gordons (Port Moresby) and Lae markets only. The final report will include the results from all surveyed regions.

The data for this report were analysed using Microsoft Excel but the aggregate survey data will be analysed using the Statistical Package for Social Sciences (SPSS).

Observations from surveys at the Gordons and Lae markets

Source of peanut

From the survey, it was observed that there is a large movement of peanuts from the Markham Valley to the Lae urban area and to other provincial markets such as Port Moresby (Figure 1). Most of the middlemen at the two markets indicated that they source their peanuts from the Markham Valley in Morobe Province (Table 1).

Table 1. The Markham Valley as the source of peanut for middlemen

Market	Total responses (%)
1. Gordons (Port Moresby)	60
2. Lae	90

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

Table 2. Preference for peanut by size and colour by different groups in the Gordons and Lae markets, Papua New Guinea (percentage responses)

Kernel type		Growers			Middlemen			Consumers		
		Gordons (N=3)	Lae (N=10)*	Av. (N=13)	Gordons (N=10)	Lae (N=10)	Av. (N=20)	Gordons (N=29)	Lae (N=30)	Av. (N=59)
1. Size	large	33	22	25	40	40	40	48	63	56
	small	0	11	8	10	10	10	14	27	20
	both	67	67	67	50	50	50	38	10	24
2. Colour	red		20	8	30	20	25	21	27	24
	white		40	31	30	30	25	52	59	55
	both	100	40	61	40	50	50	27	14	21

* One consumer did not respond to the question of preference for size.

Table 3. Consumer preference for peanut product type (%) in the Gordons and Lae markets in Papua New Guinea

Peanut Products	Gordons (N=29)	Lae (N=30)
1. Fresh pods	48	40
2. Dried pods	14	27
3. Boiled pods	21	13
4. Fried kernels	7	7
5. Roasted pods	10	13
	100%	100%

Preference for peanut type

Respondents at the market place had preferences for different peanut types (Table 2). The majority of middlemen and consumers preferred large white kernels, while most growers had no preference one way or the other regarding size and colour. Middlemen ranked size and colour the same as consumers, indicating that they are aware of consumer preferences.

Preference for product type at local markets

Consumer preference varied between the urban markets. Consumers at Gordons preferred fresh, boiled and dried peanuts whereas consumers at Lae preferred fresh, dried and boiled peanuts (Table 3). Interestingly, there was a low preference for fried kernels in both markets and thus a low threat of food poisoning.

Estimated quantity purchased by consumers in Port Moresby and Lae

It was estimated that an individual family in Port Moresby would consume an average of 265 g peanut pods per week while a family in Lae would consume 930 g per week (Table 4). However, a doubling of the price would lead to a fall in consumption of 43% in Port Moresby and 39% in Lae. In both locations, the survey showed that peanut demand would rise by 160% if the price were halved.

The data on weekly purchase (as shown in Table 4) were used up to compute the total peanut consumption

Table 4. Status of peanut consumption (per week) and changes in quantity demanded in response to change in price at Port Moresby and Lae, Papua New Guinea

Location	Average consumption per family (kg/week)	Average consumption per week if peanut price doubles (kg/week)	Fall in consumption when price doubles (%)	Average consumption per week if peanut price halves (kg/week)	Increase in consumption when price halves (%)
1. Port Moresby	0.265	0.152	43	0.688	160
2. Lae	0.930	0.566	39	2.422	160
Total	1.195	0.718	40	3.11	160

Table 5. Status of peanut consumption (tonnes/week) by urban population and changes in consumption pattern in response to changes in price in Port Moresby and Lae, Papua New Guinea

Location	Average quantity of peanuts consumed by urban population	Average quantity of peanuts consumed by urban population when price doubles	Average quantity of peanut consumed by urban population when price halves
1. Port Moresby (N*=42,403)	11.24	4.83	29.22
2. Lae (N=20,716)	19.27	7.52	50.10
Total	30.51	12.20	79.33

N= Total urban household population

by the urban population (using the 2000 population census), in Port Moresby and Lae.

It is estimated that the current urban demand for peanuts in Port Moresby and Lae is 11.24 and 19.27 tonnes per week, respectively, giving a total demand of 30.51 tonnes (Table 5). These statistics suggest that about 12% of the peanuts produced annually in the major producing provinces are consumed by the urban populations of Port Moresby and Lae. If prices rise by 100%, total demand is estimated to fall to 12.20 tonnes (a 40% drop) while if the price fell by 50%, consumption is estimated to increase to 79.33 tonnes (160% increase).

Further analysis is underway to develop similar supply–demand scenarios for other markets surveyed in the study.

Acknowledgment

The authors wish to acknowledge ACIAR for funding support, Drs R.C.N. Rachaputi, Greg Mills, and Graeme Wright for technical support, NARI for logistical support and NARI staff who assisted in the survey.

References

Wemin J.M. and Geob T. 2004. Peanut production, utilisation and marketing in Papua New Guinea: a peanut farmer survey. Project report for ACIAR Project ASEM 2001/055. National Agricultural Research Institute, Aiyura, Papua New Guinea.

Pests and diseases of peanuts in the Markham–Ramu valleys and Eastern Highlands of Papua New Guinea

J.A. Wightman[1], L.S. Kuniata[2], H. Saese[3], T. Geob[4] and Y. Tomda[4]

[1]*International Pest Management, Maleny, Queensland 4552, Australia*

[2]*Ramu Sugar Ltd, PO Box 2183, Lae 411, Morobe Province, Papua New Guinea; email: lkuniata@ramusugar.com.au*

[3]*Trukai Industries Ltd, PO Box 2129, Lae 411, Morobe Province, Papua New Guinea.*

[4]*National Agricultural Research Institute, Aiyura, PO Box 384, Kainantu, Eastern Highlands Province, Papua New Guinea*

Abstract

Records of peanut pests and diseases in Papua New Guinea needed to be updated so a field survey was conducted between April and May 2005 covering the Morobe, Eastern Highlands and part of Madang provinces. About 18 groups of insect pests were identified, the most important being aphids, white grubs, pod borers and grasshoppers. Peanut mild mottle virus was widespread and peanut rust, early- and late-leaf spot diseases were also present in most of the blocks visited. Suspected symptoms of bacterial wilt were observed in trial plots at Umi Bridge, Markham Valley.

Introduction

More than 36 species of insects have been recorded feeding on or damaging peanut crops in Papua New Guinea (PNG) (Kumar 2001; Young 1984). The most important pest species in the Markham Valley are the pod-boring earwig, *Euborellia annulipes* (Lucas) (Derm.: Labiduridae) and the larvae of the white grub, *Lepidiota reuleauxi* Brenske (Col.: Scarabaeidae) (Kuniata and Young 1992). The pod-boring earwig causes up to 40% of damage, and although there were no economic assessments made on potential losses, the damage is sufficient to exacerbate aflatoxin incidence in crops. White grub larvae have the potential to cause substantial damage by feeding on the underground parts of peanuts. Lepidopterous and chrysomelid pests are sporadic but can be easily controlled using insecticides. The aphids can act as vectors for certain viral/phytoplasma diseases.

The last records of peanut diseases were made in the late 1980s, but the observations were mainly confined to small trial plots. Shaw (1963) listed leaf spot, wilt and collar rot, and leaf mottle as important. The latest records by Muthappa (1987) listed up to 13 diseases associated with peanuts, highlighting the most widespread as *Cercospora arachidicola* Hola (early leaf spot), *Cercosporidium personatum* (B & C) Deighton (late leaf spot), *Puccinia arachidis* Speg. (rust) and *Sclerotium rolfsii* Sacc. (collar rot).

As a part of the ASEM 2001/055 project, pest and disease surveys were undertaken on peanut crops grown in the Markham Valley (Morobe Province) and Eastern Highlands Province in PNG to update the peanut pests and disease database and identify priority areas for future research to develop strategies for integrated management. This paper presents a summary of the comprehensive survey conducted by J.A. Wightman in 2005 in the extension phase of the project.

Material and methods

A survey was conducted between 26 April and 4 May 2005 covering the Morobe, Eastern Highlands and part of Madang provinces, PNG. Two village areas (Noa and Muyar) near Bubia, Lae, Morobe Province were visited on 26–27 April. The lower Markham Valley area (Riara, Gampiaru and Trukai farms) was visited on 28 April. Eastern Highlands Province was surveyed on 30 April and 1 May, covering the following villages near Kainantu and Aiyura – Maropa

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

'mountain top', Bovonave, Kandware, Kamano, Aiyura and Maropa. The survey of the upper Ramu Valley, in Madang Province covering Sausi, Asas, Kesowai, Menia and Kuskapo villages was carried out on 2 May. The final area surveyed was the upper Markham Valley on 3 May. The trial sites or crops near the following villages were inspected – Umi Bridge trial plots, Mutzing, Wafibampun, Atunas and Papua (near Gusap).

The survey technique involved field inspections and interviews with farmers and researchers. Insects were collected using sweep nets and aspirators or by hand picking. A spade was used to dig plants at random as well as those with symptoms of pest attack to check for soil pests. Insects found on peanut crops in the field were tentatively identified to family groups. More familiar insects were identified to genus and species levels. Samples of insects collected (and their damage) were photographed and then preserved in 80% ethanol and held at Ramu Sugar.

Observations on diseases were made by looking for disease symptoms in standing peanut crops in the field. Dying plants were also cut longitudinally for symptoms of bacterial wilt. Plants were also dug out to observe any soilborne diseases that may affect the roots and pods. No specimens were collected and preserved.

Results

Aphids (probably *Aphis craccivora*) were found at varying densities in all areas (but not in all gardens) on crops from the two-leaf stage to first flowering (Table 1). Sweep netting of mature crops in the upper Markham Valley yielded a small number, indicating that migration from the mature plant (normal for this species) was not complete. Damage was restricted to wrinkling of the terminal leaflets. Densities were relatively low compared to experience elsewhere. These pests are of economic importance as persistent and non-persistent vectors of viruses. They are the most likely vector (other than seed) of peanut mild mottle virus (PMMV), which was pandemic. Ladybird and syrphid larvae are effective predators of aphids: both were present in aphid infested gardens and can be assumed to be the most significant determinants of aphid density (Table 2).

Jassids (probably *Empoasca* sp.) were found in every field visited (Table 1). Their feeding damage is conspicuous, but rarely reached 'hopper burn'. Their damage symptoms can be confused with leaf scorch. Jassids are found on peanut crops throughout the Asia–Pacific region. Their feeding symptoms can be severe. Because jassids usually occur in conjunction

Table 1. Insects and damage symptoms to peanut plants encountered, with an indication of their damage potential

Pest species	Morobe Province		Eastern Highlands Province
	Intensive	Long fallow	
Aphids, probably *Aphis craccivora*	2	(0)	2
Jassids, probably *Empoasca* sp.	1	1	2
Jassid symptoms	1	1	2
Bored pods	2	1	1
Earwigs (Forficularidae)	1	0	0
False wireworm beetle (Tenebrionidae)	1	0	1
False wireworm larva (Elateridae)	1	0	0
White grubs *Lepidiota* (*reuleauxi* and *vogeli* in Eastern Highlands Province)	2	0	2
White grub damage to pods	2	0	0
White grub damage to roots	0	0	2
Mealybugs on roots, pegs, pods, and leaves 'Coccoidea'	1	0	0
Stem borer	1	0	0
Tip borer	1	0	1
Thrips	0	0	0
Thrips symptoms (leaf dotting and *Frankliniella* type feeding)	1	1	1
Grasshoppers (numerous but not economic)	2	2	2
Orobius and other weevils	0	0	1
Agrotis (cutworm)	1	0	1
Spodoptera, Helicoverpa and other lepidopteran defoliators	0	0	1
Flea beetles (Buprestidae)			
Mirids (Heteroptera, Miridae) possibly three species including *Creontiades*	1	1	0

0 = absent; 1 = sporadic and sub-economic; 2 = common to pandemic, possibly economic

Table 2. Natural control agents encountered in peanut crops during the survey in the Markham–Ramu valleys in the Eastern Highlands of Papua New Guinea

Group	Comments
Spiders	Probably the most important predator. Many species Very sensitive to insecticides Not collected
Ladybirds	Probably *Harmonia* spp. and *Coccinella* spp. In collection. Not as many as expected, despite common occurrence of aphids
Mantids	Present but not numerous Sign of a healthy system
Syrphids	Not common, larvae associated with aphid colonies
Tiger beetle larvae (Cicandelidae)	Common in some fields in both areas (collected)
Ants	Can be predators of defoliators and can protect aphids — neither group is common. One genus (*Dorylus* sp.) is known to be a pest of peanuts in Asia and Africa. It was not found.
Birds	None seen in fields: key predators apparently absent.
Entomophagous fungi	White grub pathogen collected: known to farmers near Aiyura (collected)

with a range of pests, a relationship between their density and yield loss has not been established, but may exist. Jassids can spread viruses in a non-persistent manner.

Mirids (apparently 2–3 species) were collected by sweep netting (Table 1). Densities observed were low — 1–5 per 20–30 sweeps. Their presence is highlighted because they can reduce the yield of peanut crops by destroying flower buds, even at low densities. Mealybugs, up to 3 mm in length, were found on the roots, pegs and pods of several fields in the lower Markham and in the western end of the Ramu Valley (Sausi-Kesowai in Madang Province). Farmers were aware of their presence but considered them to be of no importance. One plant with matured adults (egg sacs) and crawlers on the leaves was found in the upper Markham.

Defoliators normally have little impact on peanut plants because the plants have a high leaf area index. Pod yields are unaffected even after >50% defoliation (Wightman et al. 1990). The noctuids, *Spodoptera* spp. (Eastern Highlands Province) and *Helicoverpa armigera* (upper Markham) were present at barely detectable densities. Lepidopteran stem borers were mainly detected in the lower Markham, the upper Ramu Valley (Sausi area in Madang Province) and fewer in the upper Markham. The caterpillar hollows out the stem. Two species were present, one of which pupated in the stem. The appearance and activity, but not the severity, of the smaller stem borer is akin to *Elasmopalpus lignosellus* the lesser cornstalk borer, a major peanut pest in the south-eastern states of the USA (Smartt 1994). This species normally feeds on the pods, but bores the stem when the soil is wet. The other, larger, species chewed an emergence hole in the stem and presumably pupated in the soil. It has the appearance of a gelechiid. Larvae were collected for rearing in the laboratory. They were not at densities likely to reduce yields. A small number of stem terminals had been chewed by small lepidopteran larvae (mainly in Eastern Highlands Province). They appeared to be the same or a similar species as the smaller stem borer.

Grasshoppers were common everywhere and there was a rich diversity of species. None appeared to affect the crops, apart from a few notches chewed out of unfolding leaflets. None were collected. Flea beetles and weevils were included in the collection but there was no reason to suspect that they affect yield. Light feeding symptoms of at least two species of thrips were identified throughout the area surveyed, but no thrips were located, despite carrying out foliage extractions with ethanol. This taxon is flagged for vigilance in future surveys. Several species of thrips have been identified as vectors of peanut (tospo) viruses (Smartt 1994).

White grubs are among the most serious of all peanut pests on a worldwide basis. This is because the ‘fruit’ is fully exposed to these comparatively large and mobile insects. Feeding activity on the root may result in rapid plant death because it is cut through, or a slower death as a result of the invasion of a soilborne pathogen and the subsequent build up of pathogen propagules in the soil. A heavily attacked field in Ramu Valley had been reduced from a sowing density of 20 plants/m^2 to 12 plants/m^2, with about 8 weeks to harvest, but less than 1 month before harvest the white grubs ceased to feed. This mirrored a similar situation in Eastern Highlands Province where the grub density was lower, but the plants were smaller and more susceptible to

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

attack. A similar degree of stand depletion was noted and of concern to the farmers. It should be noted that in fields with even a moderate density of grubs (i.e. in the range 1 grub/1–10 m^2) yields will be suppressed by pod destruction even if plant densities are not markedly affected as a result of root damage.

Integrated pest management procedures are available involving a combination of cultural practices and strategic pesticide application.

Wireworms (Elateridae), false wireworms (Tenebrionidae) and earwig borers are all of concern in Papua New Guinea. Field data indicate that earwigs are the most serious, with localised patches of high incidence (L.S. Kuniata, unpublished data). This survey detected gardens with pod damage ranging from 0–100%, with an average of about 15% in short-rotation areas. Incidence was highest in the lower Markham and lowest in the long rotation fields of the upper Markham Valley. The damage symptoms consisted of symmetrical bore holes of about 2 mm diameter attributed to earwigs, symmetrical bore holes 3–4 mm diameter attributed to false wireworms (FWW) and wireworms (WW), and irregular holes averaging 2–3 mm diameter with scarification – cause unknown – attributed by farmers to ‘red ants’.

Adults of FWW and WW (in collection) were found throughout the sampling area. Only one FWW larva was found in a pod. The presence of adults indicates that the larval period may have been complete for the current growing season.

One or two seedlings had damaged cotyledons. *Agrotis* cutworm larvae were associated with the plants, which were also infected with a (*Pythium*?) collar rot. No millipedes were found.

Diseases

Early leaf spot (ELS) (*Cersospora arachidicola*) and/or late leaf spot (LLS) (*Cersosporidium personatum*) are common wherever peanuts are grown (Table 3). They are so common that farmers, worldwide, consider the defoliation caused by these species to be the signal to harvest the crop.

They were present throughout the area surveyed. ELS was always present, but LLS was not always found in the Markham Valley. Low incidence was observed in several long rotation fields the upper Markham Valley that were being harvested at the time of the visit. The high incidence observed in Eastern Highlands Province, even in crops in the flowering/early pod swelling stages, was probably associated with the poor nutritional status of crops.

Management options include breaking the infection cycle by removal of crop residues and deep ploughing and the strategic application of fungicides.

Table 3. Peanut plant diseases and symptoms encountered, with an indication of their intensity

	Morobe Province		Eastern Highlands Province
	Intensive	Long fallow	
Early leaf spot	2	1	2
Late leaf spot	0–1	0	2
Rust	1	0	1–2
Web blotch	0	0	1
Leaf scorch/pepper spot	1	1	1
Peanut mild mottle virus	2	2	2
Verticillium root and stem rot	1	0	2
Sclerotium rolfsii root rot	1	0	1
Pythium/collar rot (suspected)	0	0	1
Bacterial wilt is suspected			

0 = absent; 1 = sporadic and sub-economic;
2 = common to pandemic, possibly economic

The successful implementation of a management plan would almost certainly double yields.

Rust (*Puccinia arachidis*) was common throughout, but was less intense than the leaf spots. The uridiospores of this disease only survive for a short time in the soil, but are carried by air currents. As this disease attacks only *Arachis* spp. it can be contained if there is a significant break in the growing season and if volunteer growth is removed. The disease can also be managed with fungicides, calexin being the favoured ingredient.

A low incidence of leaf scorch and an even lower incidence of pepper spot were found throughout. The causal agent of both is *Leptosphaerulina crassiasca*. This disease was most abundant in the variety trial at Umi Bridge. The ICGV varieties now being promoted need to be checked to determine whether any are more susceptible than the local varieties.

Web blotch (*Phoma arachidicola*) was found in one field in the Eastern Highlands Province (Maropa ‘Mountain Top’). *Sclerotinia minor* (a fluffy white growth on the crown) was identified on one plant in the Ramu Valley (Kesowai, Madang Province). Stem rot (*Sclerotium rolfsii*) was present on dead, sick and dying plants. Two plants were found in the Ramu Valley (Kesowai, Madang Province) with orange growths (spots) on the lower stem, crown and underground parts. These were probably the sclerotia of *S. rolfsii*. This disease often appeared to be associated with *Verticillium* wilt.

Verticillium root rot (wilt) (*V. dahlia* or *V. albo-atrum*) was conspicuous by the vascular browning in dead and dying plants in all areas. It caused up to 50% mortality in the most overworked soils in Eastern Highlands Province, but was also an issue in the western end of the Ramu Valley (Kesowai-Sausi, Madang Province).

The variety trial at Umi Bridge was visited on the final day in the field. A few plants with a single wilted stem were observed. This and a brown crown rot are symptomatic of bacterial wilt (*Pseudomonas solani*). Bacterial wilt occurs throughout Asia and is a particular problem in the archipelago that includes PNG and Indonesia.

In retrospect, it is possible that some of the dead plants that were diagnosed as exhibiting terminal symptoms of *Verticillium* wilt and stem rot had died of a bacterial wilt infection. This is worth investigating in future. This disease can be serious (e.g. 90% plant mortality) and there is no known chemical intervention. Management practices include rotation with a graminaceous plant (grass, rice, maize or sorghum). If *Verticillium* wilt is an issue, it is currently a minor one, perhaps because grass fallows feature highly in the endemic management patterns. It is also possible that the landraces have evolved resistance to *Verticillium* wilt. Newly introduced varieties should be checked for *Verticillium* wilt. Symptoms were seen at the Umi Bridge variety trial.

Peanut mild mottle virus (PMMV) was found at varying levels of intensity in all fields (Table 3). The symptoms are inter-veinal wrinkling, a downward curl of the lateral leaf margins and a chlorotic mottle. The virus is transferred through the seed and by aphids (and perhaps jassids). There is no known remedy and it probably has little effect on yield. New varieties should be checked for extreme symptoms.

Witches' broom (phytoplasma) was occasionally seen in plants of all ages. Its wide distribution shows that it has been in the country for a long time and is no longer a concern for the PNG quarantine service. Its presence in seedlings does not indicate it is seed-borne because affected plants do not produce seeds — it sterilises the host. Its mode of transmission is not clear but if insects are the vectors they are relatively inefficient as the most likely vectors (aphids and jassids) were 'everywhere' in this survey. This situation seems to be a prime target for a roguing (removing diseased plants) campaign by NARI, NAQIA and DPI (PNG).

Discussion

More than 17 groups/species of insect pests were encountered during the present survey (Wightman 2005). Probably the species of mealybug encountered during the survey has not previously been included in the peanut fauna. Future investigators are encouraged to monitor crops for mealybug infestations and to consider whether they depress yields. Sucking insects (aphids, mirids and jassids) were present throughout. They are of unknown (but probably small) significance at the densities encountered. Aphids spread viruses (and peanut mild mottle virus is pandemic). Other peanut viruses are pandemic in the archipelago which includes PNG. Should a serious disease, such as peanut stripe virus, which is widespread in Indonesia (but not Australia) enter the country the vectors are already *in situ*. If feasible and affordable, imidocloprid (Confidor®), as a seed treatment or granule (depending upon whether white grubs are present), should be tested in on-farm trials.

Leaf-chewing insects and stem borers are of no threat to productivity. Both noctuid species (*Helicoverpa. armigera* and *Spodoptera*) were not particularly attracted

White grub pest of peanut plants

White grub damage to peanut plants

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

Jassid symptoms on peanut plant leaf

Jassid damage to peanut plant leaves

to peanut but have the capacity to reproduce rapidly on this crop if natural control processes are impaired by foliar insecticide applications. Maize is a favoured host of *H. armigera* which can transfer to peanut from this crop. The same relationship exists for *Spodoptera* and tobacco.

Control of white grub larvae will be important when large areas in the Markham Valley are cultivated for peanuts or other crops. This grub is a grassland pest but has the potential to attack crops such as peanuts, sugarcane, pastures and oil palm. Successful control of white grubs has been achieved using Confidor® 200SC in sugarcane and oil palm (L.S. Kuniata, unpublished data) and this can be adopted for peanuts too. This insecticide can also be used for the control of pod-boring pests such as the earwigs and wireworms.

Early and late leaf spot diseases and peanut rust are almost certainly contributing to suppressed yields. Their impact can be reduced by introducing cultural practices that reduce the carryover of propagules from one crop to the next, and by the strategic application of fungicides. Unless soil fertility is attended to, the incremental benefit accruing from disease management will be small after additional costs have been met.

Soilborne diseases (*Verticillium* sp., *Sclerotium rolfsii* and possibly bacterial wilt), white grubs and pod borers are location specific constraints and are well known to farmers. Where present, seed should be treated with Thimet to prevent disease.

Acknowledgments

The authors are grateful to the Australian Centre for International Agricultural Research which provided funding for this survey (Project ASEM/2001/055). A number of technicians with NARI, Trukai Industries and Ramu Sugar helped in the survey.

Mealy bug damage to peanut plant leaves

Symptoms of iron chlorosis (deficiency) on peanut plant leaves from the lower Markham Valley

Thrips feeding damage to peanut leaves

References

Kumar R. 2001. Insect pests of agriculture in Papua New Guinea. Part 1. Principles and practice, pests of tree crops and stored products. Science in New Guinea. 723pp.

Kuniata L.S. and Young G.R. 1992. The biology of *Lepidiota reuleauxi* Brenske (ColeopteraL Scarabaaeidae), a pest of sugarcane in Papua New Guinea. Journal of the Australian Entomological Society 31, 339–343.

Muthappa B.N. 1987. Records of microorganisms in Papua New Guinea 1977–1986. Department of Agriculture and Livestock, Port Moresby. Research Bulletin No 43. 78pp.

Shaw D.E. 1963. Plant pathogens and other microorganisms in Papua New Guinea. Department of Agriculture, Stock and Fisheries, Port Moresby, Papua New Guinea. Research Bulletin No 1, 82 pp.

Smartt J. (Ed) 1994. 'The groundnut crop.' Chapman & Hall: London [chapters on insects, diseases, nutrition, nodulation etc.]

Wightman J.A. et al. 1990. Pests of groundnut in the semi-arid tropics. In 'Insect pests of tropical food legumes'. (Ed. Singh S.R.). John Wiley & Sons: Chichester, New York, Brisbane, Toronto, Singapore.

Wightman J.A. 2005. Pests and diseases of groundnut in Morobe and Eastern Highlands provinces of Papua New Guinea. Consultancy report submitted to ACIAR.

Young G.R. 1984. A checklist of mite and insect pests of vegetables, grains and forage legumes in Papua New Guinea. Papua New Guinea Journal of Agriculture, Forestry and Fisheries 33 (1–2), 13–38.

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

The role of women in production and marketing of peanut in the Markham Valley of Papua New Guinea

Julie Kolopen, Geoff Fahey, John Bafui and Humphrey Saese

Trukai Agribusiness Ltd, PO Box 2129, Lae, Morobe Province, Papua New Guinea; email: agronomist@trukai.com.pg

Abstract

A survey was conducted in the peanut growing settlements of Riara and Noah in the Wampar area of the Markham Valley, Papua New Guinea. Fifty-two women farmers were interviewed in September 2005 on the role of women in decision making, actual participation in peanut production, constraints and training needs. Indices were computed and used to measure the women's role of decision making, the extent of participation, the training needs and problems commonly faced by women in these settlements.

The survey revealed that crop cultivation, child care and family planning, and crop selection were key areas that women were involved in making decisions, which were ranked first, second and third, respectively, against other decisions in peanut production. Similarly, women participated heavily in activities such as seed (sourcing and storage), marketing and weeding. In terms of training needs, book keeping and savings, pest and disease control and soil fertility were ranked first, second and third, respectively, as areas that needed training. Women in these settlements identified lack of agricultural knowledge, lack of extension visits and illiteracy as major constraints to participation in peanut production in the valley.

Background

Women play an important role in societies in Papua New Guinea (PNG). In rural areas this role is even greater than the role they play in urban areas. This is because in rural areas women undertake activities such as housekeeping and child care and are often heavily involved with the farming activities undertaken by their families. However, women's role and the contribution they make in farming is often understated. In most areas in PNG the societies are male dominated and as such the contribution women make is unrecognised or understated and is also not rewarded equitably.

Case studies in crops such as oil palm have revealed, for example, that whilst women contribute a significant proportion of the labour involved, they seldom receive an equitable share of the income earned from the sale of oil palm bunches. This is often partly because cheques for payment of fruit are made payable to the husband and the cash is not shared with the wife. It is also common that even when a woman receives direct payment they are forced to give most, if not all, to their husbands. Also, women often have little or no say in where this money is spent.

There is very little information available on the extent of participation by women in peanut production in PNG, but a recent survey undertaken by the National Agricultural Research Institute (NARI) as part of the ASEM 2001/055 project has indicated that the majority of activities in peanut production are undertaken by women (Wemin and Geob 2004).

Peanut production is widespread throughout the Markham Valley of PNG and farmers in the area have a long established culture of peanut farming.

Objectives

The objectives of the survey were:

- to identify the role of women in production and marketing of peanut
- to identify the training needs of women to increase both peanut production and profitability
- to identify the constraints (including cultural) that women face in peanut production.

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

Methods

The survey was carried out in Riara and Noah settlements, two of the proposed seed village project sites in the lower Markham Valley (Wampar), where peanut is one of the major sources of income. A total of 52 women farmers representing 20% of the women farmers in these settlements were interviewed at random.

Data collection and analysis

Data on participation of women in peanut production, constraints and their training needs were collected through a survey questionnaire. A scoring system was devised to measure their roles in decision making, participation in peanut production, training needs and common constraints that hinder their participation. These scores were converted into indices as outlined below (Yeasmin 2002):

$$\textit{Index} = \textit{No. of participants} \times \Sigma(\textit{scores per parameter interviewed})$$

Statistical analysis was performed either in Excel or using Statistix software version 8.0.

Results and discussion

Peanut production

Peanut (*Arachis hypogaea* L.) is a major cash crop for the women farmers and their families in the Riara and Noah settlements in the Wampar area of the Markham Valley whilst other villages derive their income from betel nut. More than 80% of women indicated that peanut is their major cash crop which brings on average K1050 annually. This constitutes 75% of their total income, while the rest comes from farming watermelon, cucumber, coconut, and betel nut (Figure 1). Other alternative crops were farmed to supplement the income from peanuts.

Given the well established subsistence peanut culture, women are familiar with the general husbandry practices of land preparation, planting, weeding, harvesting and marketing. Women and their families have been cultivating peanut for more than 7 years, which is a fairly short period compared to villages further up the Markham Valley.

Ninety per cent of the women farmers in the surveyed region have their land ploughed by tractor before planting. Their husbands or male partners then use spades or sticks to make planting holes before seeds are sown. It was noted that 50% of the women

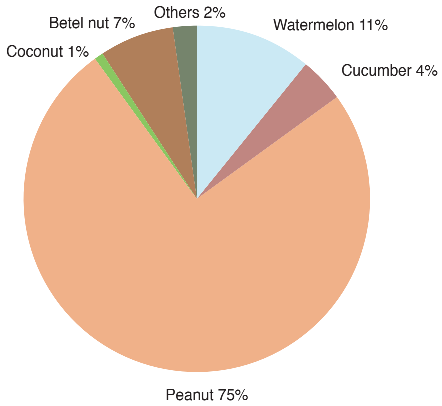

Figure 1. Household income distribution of the major cash crops in the Wampar area of the Markham Valley, Papua New Guinea

farmers tend to crop two seasons in each year: January to March for the first season and April to June for the second season (Table 1). Riara farmers grow peanut between January and June, the wettest period of the year, to achieve high yields. Other crops, such as watermelon and cucumber, are grown during the dry season (June to January).

Farmers in Riara and Noah settlements traditionally planted a popular peanut variety known as the 'pukpuk skin' or 'kona' peanut. One woman stated that some of the farmers planted a variety known as Siage, which is a strain of White Spanish with smaller pods and slightly larger kernels. During the survey, the survey team came across a variety called Aiyura, evaluated as SD–28 in the varietal trials. The relatively small number of varieties in circulation confirms the lack of varietal choice available to farmers and thus farmers are keen to have access to new peanut varieties.

Table 1. Peanut production statistics of Riara village, Markham Valley, Papua New Guinea

General production variable	Range
Peanut production history	6–7 years
Farm size	0.02–4.8 ha
Distance	0.5–0.7 km from village
Variety	1
Storage period	21–28 days
Production (ha/year)	53–76 bags
Weight of bags	23–25 kg
Price/bag	58–70 Kina
Production cycles per year	2
Average income	890–1250 Kina

Woman farmer selling peanuts in local market at Port Moresby

Decision making role of women

Women are actively involved in various decision making roles that affect their families. Traditionally in Papua New Guinea men dominate and it is generally perceived that women play very little role in decision making. In this survey women were interviewed about 10 major family activities and asked to rank their participation in making decisions in these areas. Activities ranged from crop cultivation to housing construction (Table 2). Scores from 0 to 3 were allocated to measure the extent of the women's role. A score of 0 meant no participation and 3 depicted high participation. Based on these scores a women's decision index (WDI) was computed (Yeasmin 2002) which enabled the decision making role to be quantified. Against a

Table 2. Women's decision index (WDI) for the role of women in family and farm-related activities in the Markham Valley, Papua New Guinea

Activity	High	Medium	Low	WDI	% score	Ranking
Cultivation of crops	21	24	7	112	72	1
Child care/family planning	23	16	13	103	66	2
Selection of crops	19	22	11	102	65	3
Social/religious ceremony	14	17	21	84	54	4
Income distribution	19	9	24	82	53	5
Education of children	4	28	20	72	46	6
Savings	15	10	27	71	46	6
Negotiating use of land	8	12	32	51	33	7
Rearing of animals	8	5	39	44	28	8
House construction	3	14	35	40	26	9

possible WDI of 0–156, the actual WDI ranged from 40 to 112 (Table 2). The decision-making role of women was very high in crop cultivation, selection of crops and childcare activities with a WDI of 112, 103 and 102, respectively. Contrary to the expectation that women would have little say in distribution of income, the survey revealed that they have a considerable say in the allocation of income or their family expenditure. Income distribution in this case was scored a WDI of 82.

Other activities that received a relatively high ranking in what would be considered to be dominantly a men's role were social and religious ceremonies, education of children and savings. However, it was apparent that women had very little input in decision making in issues such as house building, negotiating the use of land and rearing animals (WDI<34%). The low WDI ranking for rearing animals was because of religious taboos in the case of pigs, and the general community requirement to provide fencing which is costly. Generally, Markham Valley people supplement their protein from wild pigs and bandicoots which are abundant in the vast grasslands of the valley.

The relative spread in the WDI covering all the major aspects that affect the family unit in the valley confirms the proposition that women play an important role in raising their families.

Participation in peanut production activities

As well as their role in decision making, women are involved in various activities in farming, including peanut production. Women's participation in the various peanut growing activities was assessed using a similar scoring system, i.e. a score ranging from 0 to 5 (Table 3). Based on this score, a women's participation index (WPI) was computed, in the same way as the WDI. While the WPI ranged from 0 to 260, the WPI of 10 major peanut production activities assessed in the survey ranged from 28 to 187. The activities such as seed (sourcing and storage), marketing and weeding had WPI ratings of 187, 158, and 153, respectively. Women were primarily involved in sourcing and looking after seeds for cultivation. Most men, on the other hand, regarded marketing and weeding as the women's role. These activities require intensive labour input compared to other peanut activities. For instance, it takes patience and endurance to sit in one market position, often under direct sunlight for long periods or to manually weed for an average of 0.3 hectares with little help from anyone else.

Other activities with medium WPI values include planting, pod drying, harvesting and transporting of peanut to market (Table 3). For most of these activities women were assisted by their husbands or partners. The WPI was low for activities such as land preparation, pest and disease control and bagging of pods because women preferred to reserve time and labour for the 'Gemba' activities. Women play a major role in peanut production apart from the areas of pest and disease control. Spraying for pest and disease control using backpacks is a fairly new practice in PNG and it appears men like to be the ones to carry out this task.

Women's training needs in peanut production

The total training need index (TNI) ranged from 0 to 156. Women also indicated a need for training in

Table 3. Women's participation index (MPI) for peanut production in the Markham Valley, Papua New Guinea

Activity	Work herself		Work with partner		Hire/ contract	Do not work	WPI	Percentage score	Ranking
	Regularly	Occasionally	Male partner	Female partner					
Seed (sourcing/storage)	12	22	1	3	0	4	187	72	1
Marketing	14	9	6	2	0	11	158	61	2
Weeding	13	1	18	13	4	3	153	59	3
Transporting to market	12	8	18	3	0	11	152	58	4
Planting	13	0	14	9	4	2	139	53	5
Pod drying	4	5	24	8	5	6	133	51	6
Harvesting	3	1	20	9	13	6	110	42	7
Bagging of pods	3	0	20	7	16	6	105	40	8
Land preparation	3	0	12	1	23	4	76	29	9
Pest/disease control	1	0	7	1	0	43	28	11	10

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

Table 4. Women's training needs index (TNI) for various activities related to peanut production in the Markham Valley, Papua New Guinea

Activity	Training need				TNI	Percentage score	Ranking
	Imperative	Essential	Strongly advisable	Optional			
Book keeping/savings	44	2	2	4	138	88	1
Pest and disease control	37	9	2	4	131	84	2
Soil fertility	35	9	3	5	126	81	3
Land preparation	21	16	4	19	99	63	4
Marketing	29	2	5	16	96	62	5
Drying of pods	17	11	7	17	80	51	6
Harvesting	14	8	10	20	68	44	7
Planting	11	10	17	14	60	38	8
Bagging of pods	10	10	10	22	60	38	8
Weeding	10	0	12	30	42	27	9

land preparation techniques, marketing and post-harvest technology which received TNIs of 99, 96, and 80, respectively (Table 4). These activities were ranked as medium priority areas for training as they are performed by communities and they would generally benefit from the input of others in the family or clan. Interestingly, crop husbandry practices such as weeding, bagging, planting and harvesting had TNI scores of 27, 38, 38 and 44, respectively, suggesting that women considered themselves fairly knowledgeable about general peanut crop management. However, basic book keeping, pest and disease control and understanding soil fertility problems had very high TNIs (126–138). Traditionally, farmers tended to rely heavily on their crop's ability to resist pest infestations, disease and soil fertility decline, but this is no longer the case. The high indices imply expectations among women farmers that skilling up in these areas will place them in a better position to achieve more income from peanuts. The interest shown by women to understand and implement control measures for diseases, pests and soil fertility problems indicates that these aspects are constraints to peanut production.

Major factors hindering participation by women

The respondents indicated six major constraints in peanut production, ranging from basic literacy to lack of extension services provided by the provincial DAL, non-government organisations and other stakeholders in the agriculture industry. Constraints were measured using the problem participation index (PPI). Whilst the total PPI ranged from 0 to 156, the PPI measured for various activities ranged from 74 to 144 (Table 5). Accordingly, lack of access to information about modern agriculture was ranked as the number one constraint impeding greater participation of women in peanut production (PPI = 144). This

Table 5. Women's Participation Problem Index for peanut production

Constraints	Number of women/Category				PPI	Rank
	High	Medium	Low	Not at all		
Lack of agricultural knowledge	48	0	0	4	144	1
Extension visit	47	0	0	5	141	2
Illiteracy	27	25	0	0	131	3
Land use	29	3	12	8	105	4
Savings	21	6	10	15	85	5
Income Distribution	17	7	9	19	74	6

Woman farmer stripping peanut pods after harvesting the crop. Pod stripping is mostly done by women in the Markham Valley, Papua New Guinea

was followed by extension services, illiteracy and land use. Contrary to the popular notion that women would generally consider income distribution as a constraint, this survey showed that they did not regard it as an important constraint or an issue that would hinder them from participating in peanut production. Similarly, savings was also ranked as one of the lowest constraints. This would suggest that women do not fully value the importance of saving money from their farming activities. This is a typical scenario of rural families in PNG, where very little is saved from any farming activities. All that is earned is spent on necessities.

Conclusions and recommendations

This survey has shown that women perform a diverse and strategic role in peanut farming in the valley and has highlighted the following circumstances:

- Women actively participate in key areas of decision making — as opposed to the general notion that women are more reserved. The WDI was very high for crop selection and cultivation, childcare and to some extent income distribution in the family. The WDI was lowest for activities such as negotiating the use of land and constructing the house, which were areas where men dominate in decision making.
- Women participated in a wide range of peanut growing activities, with very high participation indices in some of the activities that would be considered as traditionally men's work.
- For women to improve and contribute to household income, they expressed a need for training in book keeping and on key aspects of crop husbandry, including soil fertility problems.

Farmer showing peanut yield in her field in the Markham Valley, Papua New Guinea

Acknowledgments

We would like to acknowledge the following organisations and individuals who provided assistance in various ways towards this survey. Firstly for funding support (ASEM 2001/055) from the Australian Centre for International Agricultural Research (ACIAR); Trukai Farms Ltd, Professor Halim and Dr Akanda from the Agriculture Department of the PNG University of Technology for commenting and making suggestions on the survey questionnaires; and Mr Isidore Sau, the assistant rice agronomist and Mr David Tima, the senior operator for their time and effort put into the survey.

We acknowledge the Kikalems and the community at Riara and Noah settlements for their hospitality and assistance during the survey.

References

Wemin J.M. and Geob T. 2004. Peanut production, utilisation and marketing in Papua New Guinea: a peanut farmer survey. Project report for ACIAR Project ASEM 2001/055. National Agricultural Research Institute, Aiyura, Papua New Guinea.

Yeasmin F. 2002. Participation of women in rice production activities and their training needs in some selected villages of BAUEC under Sadar Upazila Mymensingh District. Master of Science in Agricultural Extension Education. Bangladesh Agricultural University. Thesis, unpublished.

Best management practices manual for peanut production in Papua New Guinea

G. Mills[1], Lastus Kuniata[2] and A. Ramakrishna[3]

[1]*Department of Primary Industries and Fisheries, PO Box 23, Kingaroy, Queensland 4610, Australia*

[2]*Ramu Sugar Ltd, PO Box 2183, Lae 411, Morobe Province, Papua New Guinea; email: lkuniata@ramusugar.com.pg*

[3]*National Agricultural Research Institute, PO Box 210, Aiyura, Eastern Highlands Province, Papua New Guinea; email: a.ramakrishna@nari.org.pg*

Abstract

As a part of the ACIAR Project (ASEM/2001/055) 'Improving yield and economic viability of peanut production in Papua New Guinea and Australia using integrated management and modelling approaches', it is proposed to publish a comprehensive manual on the best management practices for peanut production in Papua New Guinea (PNG). This paper describes potential scope, content and outputs of the manual. It is proposed to release the manual by June 2007.

Scope and content

The publication will include material relevant to:
- historical background information of peanut production in PNG
- a summary of the scope and role of the industry in PNG
- current production status, geographic distribution and importance of the crop.

Technical content will cover:
- traditional production, handling and marketing of crop and the deficiencies that the current approaches present in terms of peanut yield and quality.
- best management practices incorporating modern, demonstrable and relevant agronomy techniques for the production and post-harvest handling of peanuts in PNG.

The publication team consists of Greg Mills, Lastus Kuniata and A. Ramakrishna supported by Yanding Tomda, Maria Linibi, Humphrey Saese, Julie Kolopen, Daisy Kiniafa and Timothy Geob.

Other project team members in Australia and PNG will be asked for contributions where possible, especially in evaluating the usefulness and content of the final draft publications prior to printing. ACIAR will publish the manual.

Outputs

The critical outputs relevant to PNG were discussed and revised during the project review meeting.
1. A comprehensive guide to best management practices in PNG covering all currently known background information and up-to-date production techniques.
2. A set of training guides which can be compiled as a single publication for distribution to larger smallholders involved in commercial production, i.e. more suited to Markham Valley growers and local Department of Agriculture and Livestock and service providers/trainers.
3. Smaller, simpler and targeted publications for wider distribution, highlighting improved or best practices in relation to specific aspects of peanut production including seed storage, variety selection, land preparation, planting, crop protection, harvesting and post-harvest handling of the crop.
4. The manual — 'Best Management Practices for Commercial and Smallholder Peanut Production in Papua New Guinea'.

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

Output formats for presentation of information

To be targeted to the three user levels:
1. industry professionals and agricultural educators
2. training providers/extension officers
3. farmers.

A comprehensive CD-ROM version of the manual will eventually include all information outputs relevant to the various PNG user levels. It should contain technical information, R&D outputs and local trial data, provide links to international websites and assist with access to market information, crop diagnostics etc.

An early output needs to be PowerPoint and printable versions of crop notes or '*tok toks*' in a combined publication for regional extension officers and training providers in English and Pidgin. These can be used and evaluated for content and usability in the current phase of seed village work. This publication should include crop record keeping templates and examples of profitable approaches to peanut production and marketing. The eventual comprehensive CD-ROM and hard copy version would not gain wide circulation and can function as an official reference guide to peanut production in PNG.

Pidgin versions should include simple diagrams or images demonstrating modern production techniques. They should be readily usable in terms of local application, ease of interpretation and needs of the target groups. The publication should be in colour and present a quality image of best management practices. Some complementary posters highlighting important best management practices should also be generated if the budget will allow.

Video clips or video style presentations of specific on-farm practices or with the introduction of mechanisation using CD-ROM or PowerPoint formats can be explored, depending on budget availability.

Content of the comprehensive guide

The manual will contain the following information:
- A history of peanut production in PNG
- The current role of peanuts in PNG (socio-economic value, crop distribution, food value, food security, peanut products, quality and import statistics including summary of peanut farmer survey by Wemin and Geob (2004) and market survey by Nora Omot, National Agricultural Research Institution in 2005.
- Summary of potential consumption trends, additional products and improved access to quality peanuts, value adding opportunities, health impacts etc.
- Capture critical issues for PNG peanut industry
- Best management production and post-harvest handling systems of regional PNG with special emphasis on Morobe, Eastern Highlands and National Capital District value chains including peanut production and marketing, concentrating on Morobe and Eastern Highlands provinces.
- Aflatoxin identification, health implications and management techniques, including some comparative data or experiences from other countries and a summary of the PNG aflotoxin survey.
- Information on international industry standards for edible peanut kernel including purity and food safety issues.

Agronomy

Detailed notes on agronomy should include any trial data summaries, conclusions and photographic images verifying both good and inappropriate peanut production practices in PNG. Locally recommended practices must involve accessible production technologies that are appropriate to the type of farming system, clearly explained and economically viable for peanut producers.

Best management practice topics

(a) Field selection and suitable soil types
(b) Crop rotations
(c) Inter-cropping peanuts
(d) Land preparation
(e) Crop nutrition including cadmium
(f) Nitrogen fixation and rhizobia
(g) Pre-plant weed control
(h) Peanut varieties
(i) Seed storage, seed selection and purity, germination and purchase
(j) Seed treatments and seed handling, seed inoculation.
(k) Planting guide including row spacing, plant density, sowing depth
(l) Planting and harvesting windows and production strategies.
(m) In-crop weed control
(n) Peanut diseases and management
(o) Peanut insect pests and management
(p) Crop maturity and harvesting considerations
(q) Stubble management
(r) Managing aflatoxin
(s) Threshing
(t) Post-harvest handling on-farm
(u) Post-harvest handling, farm gate to market
(v) Basic peanut processing, products and packaging
(w) Limited aspects of mechanisation of peanut production including ploughing, planting, threshing, drying and shelling for smallholders and larger commercial operations.

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

Potential issues

- Limited ability to test information outputs with stakeholders. We need to consider which formats will be most useful over the life of the project and will add value to the manual, e.g. posters, PowerPoint, videos.
- The CD-ROM will be comprehensive but the manual will be the important hard copy publication. The commercial-scale guide will largely reflect Australian best management practices.
- How can this material be continually updated?
- What planning should occur in terms of launching information products and training activities for use of these publications?

Critical actions and dates

1. November 2005 — allocation of roles to drive publications.
2. Currently available — local information from peanut pest survey (L. Kuniata/J. Whiteman).
3. Simple English drafts of peanut *tok tok* available for limited circulation in a black and white version for early 2006, to be used in current seed village work.
4. Early 2006 — inclusion of aflatoxin extension material (P. Corbett/J. Mangi) in consultation with R.C.N. Rachaputi.
5. March 2006 — summaries of farmer, market and aflatoxin surveys to be collated and outcomes included.
6. April 2006 — women's role in peanut production – implications for manual from the existing survey work (J. Kolopen/H. Saese).
7. June 2006 — development of full draft *tok tok* content including figures, graphic art, photographs and translation. Release draft manual containing full scope of content and appropriate language and terminology for general application amongst PNG smallholders for comment and feedback.
8. September 2006 — collate findings of local R&D including new varietal recommendations with relevance to best management practices manual. Feedback on draft content and application of manual and *tok toks*. Comprehensive photographic record of key on-farm activities relevant to PNG. Checklist to be developed to cover scope of requirements for all extension information.
9. October 2006 — Final drafts of the 'Best Management Practices Manual for Peanut Production in Papua New Guinea' hard copy version in English and *tok tok* version in Tok Pisin.
10. June 2007 — Release of best management practices manual in English and Tok Pisin versions.
11. Publication of CD-ROM version of compendium of best management practices in peanuts including revisions of extension material including *tok toks*, posters and flip charts in PowerPoint format available for distribution by June 2007.

Reference

Wemin J.M. and Geob T. 2004. Peanut production, utilisation and marketing in Papua New Guinea: a peanut farmer survey. Project report for ACIAR Project ASEM 2001/055. National Agricultural Research Institute, Aiyura, Papua New Guinea.

Project team planting a peanut trial

Remote sensing applications for peanuts in Australia and Papua New Guinea

Graeme Wright, Andrew Robson and Rao C.N. Rachaputi

Department of Primary Industries and Fisheries, PO Box 23, Kingaroy, Queensland 4610, Australia; email: graeme.wright@dpi.qld.gov.au

Abstract

Remote sensing imagery of peanut crops using multispectral satellite and simple infra-red (IR) airborne camera platforms offers growers and industry personnel a cost-effective technique for the assessment of 'spatial' variability in crop performance for potential applications including production forecasting and segregative harvest management. Satellite imagery of the northern Markham Valley in Papua New Guinea (PNG), and its subsequent processing using ENVI software, showed there is good potential for this technology to be used to assess regional peanut production throughout PNG. Similarly, in Australia, a combination of satellite and aerial IR imagery used throughout a season, in conjunction with change detection software techniques, can be used to identify high aflatoxin risk zones which can then be used by growers to segregate harvest areas to maximise gross returns.

Introduction

Remote sensing of crops involves the acquisition and analysis of information without physical contact, via a range of sensors such as digital cameras, radar or multi-spectral scanners mounted on aircraft, satellites or ground based platforms. Low-cost airborne and satellite remote sensing systems are becoming more widely used in Australian agriculture, predominantly for their ability to provide a synoptic view of the spatial variability of plant vigour within a crop via infra-red (IR) reflectance, and thereby indicate spatial variations in productivity (Lamb 2000).

Recent studies conducted at the Department of Primary Industries and Fisheries (DPI&F), Kingaroy, Queensland, Australia have clearly shown that the spatial variability for yield and quality is one of the major constraints to achieving the genetic potential of currently grown commercial varieties, and hence limits profitability of peanut crops grown under both irrigated and dryland conditions. Recent developments in field-scale remote sensing technologies using near-infrared reflectance (NIR) technologies can now offer researchers, agricultural consultants, and ultimately growers, the potential to better assess and manage this 'spatial variability'. Variations in NIR reflectrance captured from aerial and satellite platforms, for instance, have been correlated with in-field crop performance under a range of biotic and abiotic stress conditions. In these studies, strong correlations have been observed between parts of the NIR region of the electromagnetic spectrum and maturity variations, leaf disease infection (leaf spot and rust), aflatoxin incidence and pod yield in dryland and irrigated peanut crops (Wright et al. 2002, 2004; Robson et al. 2004). This spectral information could provide peanut growers with opportunities to implement in-crop management strategies, such as selective spraying for disease and segregation of crop regions within a field at harvest to optimise yield and quality. As well, there is the potential to use NIR remote sensing technologies, such as satellite imagery to identify all peanut crops on a regional scale using sophisticated image processing and classification techniques, as well as for production and yield forecasting applications at the industry planning level.

In Papua New Guinea (PNG) peanut is an important cash crop, rated as one of the top five income earning crops in major production systems (Wemin and Geob 2004). It is also playing a major role in the cropping intensification programs being followed by PNG smallholders. Although legume crops such as peanuts are known to be effective in maintaining soil fertility, there is little knowledge on the area and productivity of peanuts (or other crops) and their role in sustaining various production systems in PNG. Hanson

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

et al. (2001) assessed land resource potential and agricultural pressure for the five highland provinces in PNG by combining databases of land, environmental resources, agricultural intensity and rural population. These databases are combined using either cartographic overlay or geographical information systems (GIS), and have resulted in the preliminary assessment of land resource potential and agricultural pressure in PNG. The study has not been able to assess and track the dynamic changes that have been taking place in agricultural intensification, especially the variation in crop production and productivity on a real-time basis.

The NIR remote sensing technologies discussed above potentially offer a tool to monitor peanut (and other) crops on a real-time basis in PNG. The National Agricultural Research Institute (NARI) and Ramu Sugar are very keen to evaluate the use of the technology to monitor production areas, yield potential and spatial variability in peanut crops. The technology offers a potential tool to improve crop monitoring capacity by NARI at the national level, and also to add significant value to the current GIS unit based at NARI headquarters in Bubia, Lae.

The proposed R&D program in the new ACIAR project (ASEM 2004/041) will explore various options for remote sensing imagery including high-resolution imagery captured from the US Quick Bird satellite to verify and further assess the above-mentioned in-season management applications. This paper reports on some preliminary activities initiated in the extension project to assess mechanisms and linkages to access satellite images from the US based DigitalGlobe, as well as to initiate pilot studies on image processing including ground truthing at targeted sites in Queensland and PNG. The paper also covers a number of training activities conducted with NARI and Ramu Sugar scientists in image processing, GIS, recording of global positioning system (GPS) coordinates and collecting ground truthing information on standing crops at the target sites.

Methodology

Basic theory of remote sensing imagery in crop plants

Variations in crop vigour can be remotely sensed via the differential reflectance of sunlight within the IR spectral region (around 720 nm). Areas of large actively growing biomass canopies reflect more IR than areas with smaller and less vigorous crops which may be affected by constraints including high disease incidence, poor nutrition and low plant stands. A schematic diagram of the principles underlying reflectance of IR light from peanut canopies is shown in Figure 1.

IR imagery of field crops can be acquired using either satellite or airborne platforms, with both methods utilised by the DPI&F team. A simple airborne digital camera system developed by the DPI&F peanut team uses a 3CCD digital video camera, which is sensitive to IR light derived from an IR filter placed over the camera lens. Multi-spectral (red, green, blue, IR bands) satellite images can also be acquired from a range of suppliers, with the DigitalGlobe Quick Bird satellite preferred for the peanut imaging work, where high resolution (2 m^2/pixel) images are needed to detect spatial variations in crop performance.

Figure 2 shows the normal colour (bottom left) and variations in IR reflectance (top right) of a peanut crop under a poorly set up pivot irrigation system. The IR image clearly shows regions of high canopy

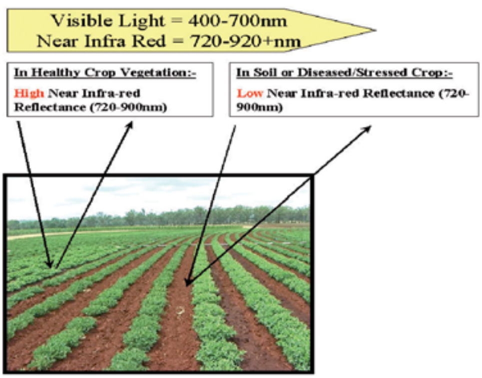

Figure 1. Schematic diagram of the principles of remote sensing of infra-red light in crop canopies

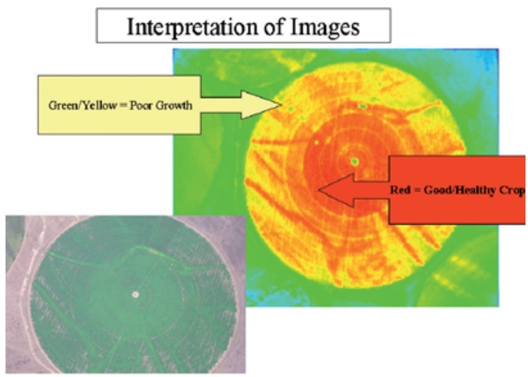

Figure 2. An example of aerial images from a peanut pivot, showing colour enhancement of infra-red reflectance from the crop canopy

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

Figure 3. Graeme Wright showing Yanding Tomda and Timothy Geob how to operate a global positioning system unit for ground truthing of peanuts fields in Papua New Guinea.

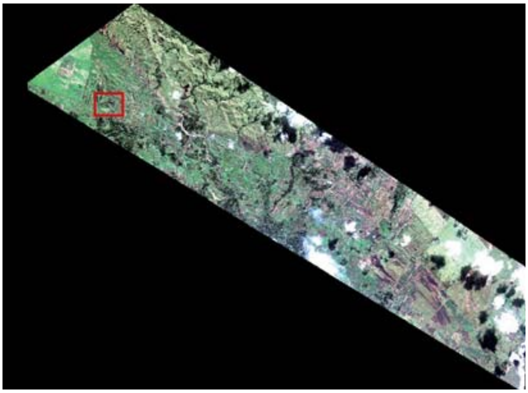

Figure 4. Normal colour scene of upper Markham Valley, Papua New Guinea. The areas of the image is approx 100 km^2.

reflectance (high biomass/vigorous growth) as dark red colouration, and regions of low canopy reflectance (low biomass/poor growth) as yellow-green colouration.

Results and discussion

Training activities

New non-differential GARMIN GPS units have been supplied to PNG collaborators at NARI and Ramu Sugar. Training in the use of these units to mark exact locations (latitude/longitude) within target crops for future ground truthing to aid analysis of satellite imagery captured in PNG was carried out during the February-March 2005 visit by R.C.N. Rachaputi and G. Wright, as well as during training visits by Yanding Tomda and Timothy Geob in April 2005 (see Figure 3).

A single computer (HASP) licence for the ENVI image analysis software has been purchased for the Australian program and is now operational at Kingaroy. Similar licensing systems for this software have also been purchased for PNG and are now in place at both NARI and Ramu Sugar. A training workshop in the use and application of this software was conducted following the final review and planning meeting on 24 October 2005 at Ramu Sugar. NARI and Ramu Sugar participants are now well acquainted with the operation of the software and will collaborate with the Australian researchers in future imagery activities in PNG.

Ground truthing of satellite imagery

Two Quick Bird high resolution, multi-spectral satellite images of peanut cropping regions in the upper Markham Valley of Papua New Guinea and Wooroolin areas of the South Burnett region of Queensland were acquired during late May 2005 and February 2005, respectively.

Studies in Papua New Guinea

In late May 2005 a Quick Bird multi-spectral (red, green, blue, IR band) satellite scene of the upper Markham Valley was acquired (Figure 4). This area covered the southern section of Ramu Sugar (top left) down to Umi Bridge (bottom right). During the February–May 2005 period GPS readings were recorded for a number of peanut crops identified within this region by ground truthing. Processing of this imagery using ENVI software included the indexing of the visible red and IR spectral bands using normalised differential vegetation index (NDVI) over the entire

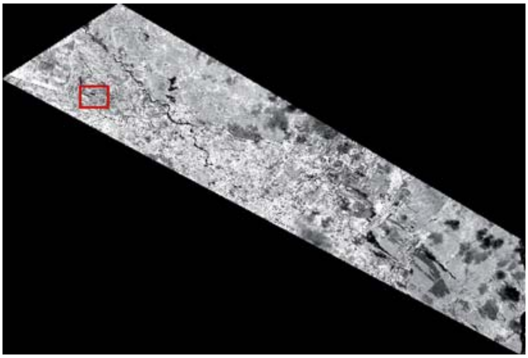

Figure 5 Normalised differential vegetation index scene of Upper Markham Valley, Papua New Guinea. Note red square (upper left) where further processing was performed on actively growing peanut crops.

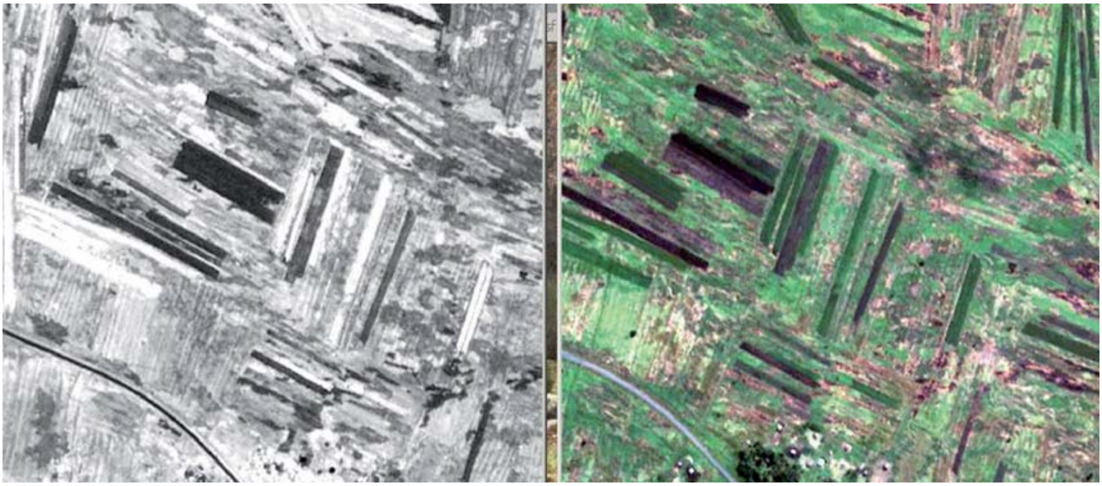

Figure 6. Normalised differential vegetation index (NDVI) (left) and normal colour (right) of subset region near the Water Rais road junction, Markham Valley, Papua New Guinea. Note bright white regions of NDVI scene that denote high crop infra-red reflectance from peanut crops.

region (Figure 5). This reduced the amount of error associated with soil reflectance and shading interfering with the canopy reflectance. A subset of this scene (red square in Figure 5) just north of the Water Rais road junction contained a number of actively growing peanut crops, which had earlier been ground truthed by project staff. Figure 6 shows the normal colour and NDVI classification of this subset region.

A further supervised classification (Spectral Angle Mapper) was performed on the entire satellite scene to identify all peanut crops using a combined NDVI-IR, red, green, blue spectral bundle, with the NDVI and IR bands already known to correlate well with ground-truthed crops (Figure 7). The magnified sub-set region, better identifies the red areas denoting 'predicted' peanut fields within the scene. Clearly, this technology and the associated analysis shows considerable promise as a tool to assess regional peanut production (area) throughout PNG. More ground truthing of peanut crops is, however, needed to confirm that the classification technique used is accurate enough to conduct this analysis. This activity will be a major focus of the new ACIAR project which is due to commence in early 2006.

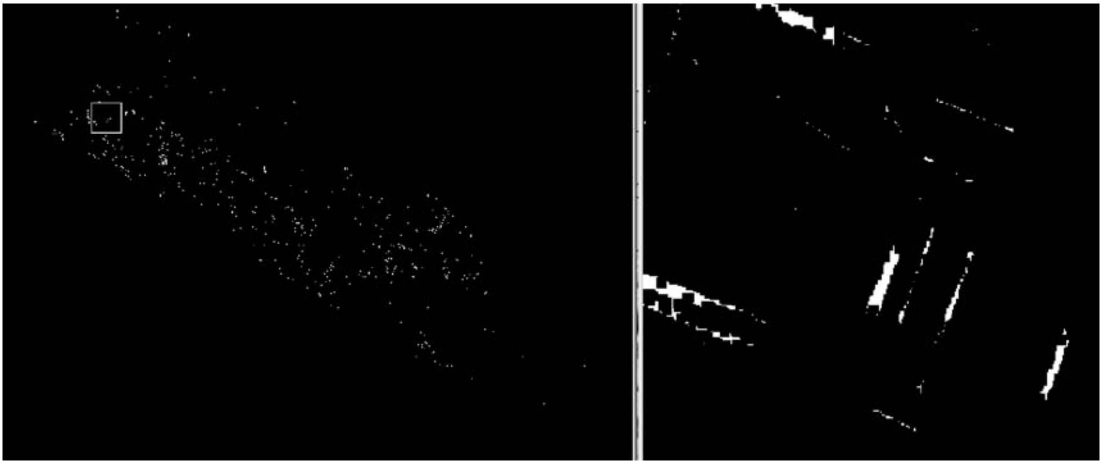

Figure 7. A supervised classification identifying 'expected' peanut crops based on the normalised differential vegetation index—infra-red reflectance signature on the sub-set region (right) + the entire satellite scene (left); Markham Valley, Papua New Guinea.

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

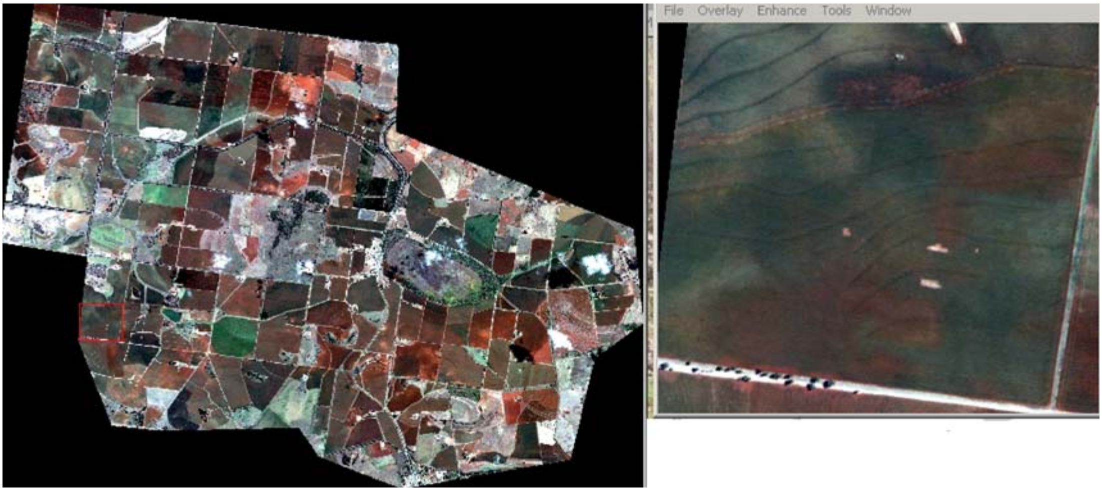

Figure 8. True colour scene (red, green, blue) of Wooroolin region, Kingaroy, Queensland including a sub-set of the field on Ritchings' farm

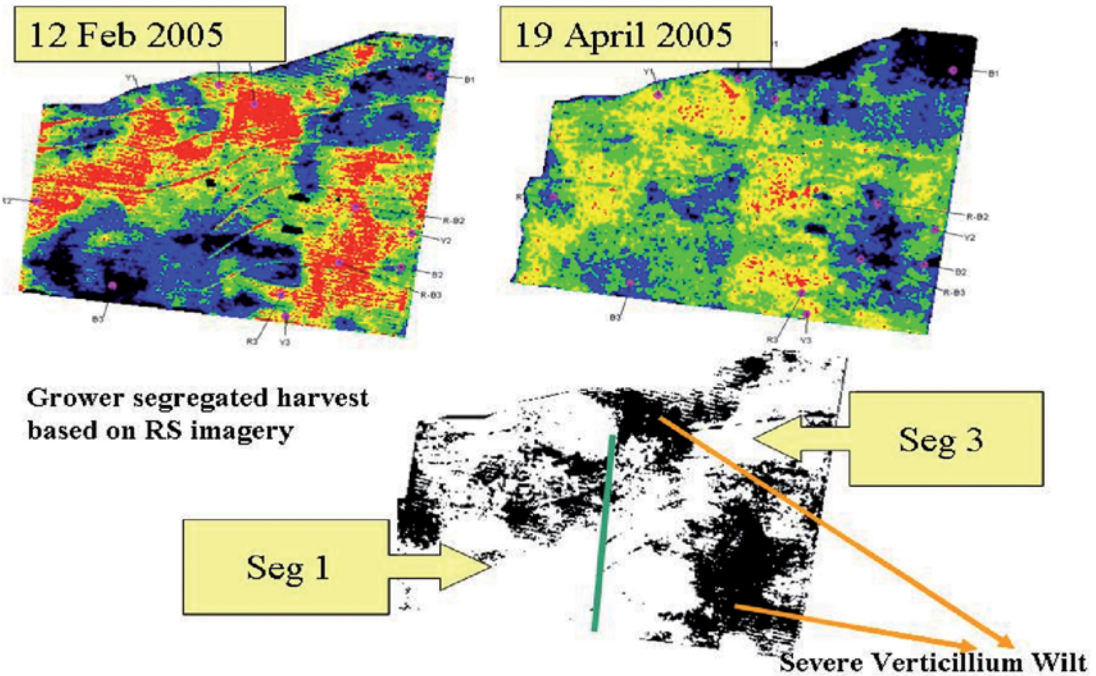

Figure 9. Change in normalised differential vegetation index of a field on Ritchings' farm, Kingaroy, Queensland from 12/2/05 to 19/4/05, and change detection (as black and white image) as determined from a supervised classification using ENVI software. Dark areas indicate a major reduction in infra-red reflectance resulting from a severe verticillium wilt infection.

Dr Graeme Wright providing training on crop modelling and remote sensing research at Ramu Sugar in the Upper Markham Valley

Australian studies

During the 2004–05 peanut season, a Quick Bird satellite image was taken of the Wooroolin region (12 Feb. 2005), approx 20 km north of Kingaroy (Fig. 8). Approximately 4000 ha of peanuts are grown in this region, with a number of peanut fields being intensively monitored during this season for remote sensing applications, including a range of harvesting management decisions.

One field (on Ritchings' farm – see subset in Figure 8), was imaged on a number of other occasions during the season using aerial IR imagery. The additional temporal images enabled a change-detection image processing technique to be used that identified regions of the crop that changed rapidly from 12 February to 19 April. Figure 9 identifies the significant spatial variability in crop performance arising from severe drought and late-season disease attack. Specific regions of this crop had become highly infected by the verticillium wilt disease (dark area in the change detection figure) and potentially had a much higher risk of aflatoxin contamination. Based on this processed imagery, the grower decided to segregate the harvest in this field into two major areas – one with severe disease incidence and the other with little change. The final outcome was that the area with minimal change (and hence lower drought and disease incidence) was free from aflatoxin contamination, while the high change area had severe aflatoxin contamination a toxin identified to be more prevalent in stressed regions of a crop (Wright et al. 2002), as subsequently measured in loads of peanuts delivered to the buying point in Kingaroy. This decision meant the grower received a much higher return (i.e. lower aflatoxin penalties and worth many thousands of dollars) than if he had harvested the entire crop as one lot. This example provides clear evidence that this technology can offer commercial benefits to peanut growers.

References

Hanson L.W., Bourke R.M., Allen B.J., McCarthy T.J. 2001. Mapping land resource potential and agricultural pressure in Papua New Guinea. ACIAR Technical Report 50. 52p.

Lamb D.W. 2000. The use of qualitative airborne multi-spectral imaging for managing agricultural crops — a case study in south-eastern Australia. Australian Journal of Experimental Agriculture 40, 725–738.

Robson A., Wright G. and Phinn S. 2004. Assessment of peanut crop maturity and yield forecasting with Quick-Bird multispectral satellite imagery. Spatial Science Queensland 4, 35–37.

Wemin J.M. and Geob T. 2004. Peanut production, utilisation and marketing in Papua New Guinea: a peanut farmer survey. Project report for ACIAR Project ASEM 2001/055. National Agricultural Research Institute, Aiyura, Papua New Guinea.

Wright G.C., Lamb D.W. and Medway J. 2002. Application of aerial remote sensing technology for the identification of aflatoxin affected areas in peanut fields. In 'Proceedings of 11th Australasian Remote Sensing Conference', Brisbane, Queensland, Sept. 2002.

Wright G., Robson A. and Mills G. 2004. Application of remote sensing technologies to improve yield and water-use efficiency in irrigated peanuts. In 'Proceedings of the 4th International Crop Science Conference', Brisbane, Australia.

A pilot on-farm trial using a 'seed village' concept for extension of improved practices for peanut production

Lastus S. Kuniata[1], Miriam Otto[1] and Julie Sip[2]

[1]*Ramu Sugar Ltd, PO Box 2183, Lae 411, Morobe Province, Papua New Guinea; email: lkuniata@ramusugar.com.pg*

[2]*National Agricultural Research Institute, PO Box 210, Aiyura, Eastern Highlands Province, Papua New Guinea*

Abstract

The Markham Valley has the potential to become the 'food bowl' of Papua New Guinea. Peanut is one of the most popular crops adapted to the region and there is scope for major increases in productivity of the crop by implementing improved varietal and crop husbandry practices. As a part of the ASEM 2001/055 project, a pilot on-farm trial was conducted from February to June 2005 to evaluate the 'seed village' concept to see if there are any issues with implementing such on-farm trials on a wider scale.

The pilot study was the first of its kind in the valley, and brought researchers, extension personnel and growers together to achieve a common goal — i.e. to improve peanut production. A field day was held to demonstrate the effects of varieties and management practices to smallholders in the region. The day attracted a lot of interest from farmers, researchers and extension personnel. The on-farm pilot trial also provided an opportunity to assess farmers' perceptions on new varieties and new practices. The results clearly demonstrated higher yields obtained with new varieties grown under improved practices. The study demonstrated the 'seed village' concept as an effective medium to extend new varieties and management technologies to smallholders.

Introduction

The Markham Valley is a large structural depression that occupies a geologically unstable area in Papua New Guinea (PNG). At the upper reaches of the Markham Valley is the Ramu Valley that extends some 300 km north-west into Madang Province. The Markham/ Ramu Valleys have the potential to become the 'food bowl' of PNG. This area currently produces all the sugar, up to 45% of beef, and up to 60% of poultry products for the PNG market. Other agricultural products produced here include peanuts, maize, bananas, rice and pork. Those crops that have potential to impact significantly on the rural communities in the Markham/Ramu Valleys are peanuts, maize, rice and cassava.

A soil survey conducted in the early 1970s revealed that the Markham Valley has a moderate to very high potential without reclamation for 23,400 ha of arable crops (such as sorghum, dryland rice, sugarcane, peanuts and maize), more than 56,400 ha for improved pastures (at two animals per ha, this would represent more than 120,000 head of cattle) and 12,300 ha for tree crops (Holloway et al. 1973). With reclamation, the total area can be increased to 235,000 ha including a potential area of 42,300 ha for irrigated rice (Table 1). More than 30 years on, this potential in the Markham Valley has still not been realised.

The on-farm study involving farmers in the evaluation of the new peanut varietal and management technologies on farmer fields is a first step towards extending the new technologies to smallholders. The

Table 1. Land potential in the Markham Valley, Papua New Guinea (Holloway et al. 1973)

Type of development	Without reclamation (ha)	With reclamation (ha)
Arable crops	23,400	62,200
Improved pastures	56,400	79,300
Tree crops	12,300	51,100
Irrigated rice	0	42,300
Total area	92,100	235,000

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

Table 2. Details of local and improved practices used in the seed village trial for improved peanut production in the Markham Valley, Papua New Guinea

Operations	Local	Improved
Land preparation	Tractor	Tractor
Seed dressing	Soak in water overnight	Thiram and acephate at 1g/kg seed; Ethrel® at 0.02%
Sowing	Plant in rows 40 cm × 10 cm	Plant in rows 40 cm × 10 cm
Fertiliser	Nil	Side dressing with 30 kg K/ha and 18 kg P/ha; basal lime at 100 kg/ha
Inter-culture/weed management	As needed	Weed-free
Pest & disease management	Nil	Pests — permethrin at 750 mL/ha on fortnightly basis; diseases — Bravo fungicide on fortnightly basis from 70 days after planting
Harvest	Leaf colour	Based on inner shell wall colouring — blackening with over 70% nuts
Post-harvest	Sun dry and store	Sun dry to less than 10% moisture

farmer's site on which the farmer-participatory on-farm trial is conducted is known as a 'seed village'. The land of the seed village trial may be owned by either a single farmer or a group (not more than three) of farmers.

The seed village sites are the platforms for demonstrating the new varieties and management practices, organising field days and extending these technologies to local farmers.

In this case, new high-yielding varieties identified from the previous varietal trials are evaluated in farmers' fields to demonstrate the value of new varieties and crop husbandry practices. As well, seed village trials also provide the source for multiplying seeds of new varieties.

Material and methods

The on-farm trial was planted in mid-March and was harvested in mid-July 2005. The following varieties — ICGVs 94299, 94341, 92160 and Yarang (local check) — were planted using both local and improved practices. The improved practices involved seed dressing with thiram fungicide, fertiliser application (lime, triple superphosphate, muriate of potash), pest and disease control as described in Table 2. Local practices consisted of those practices which the farmer traditionally carries out.

Planting was done manually. The crop under improved practice received two sprays of permethrin at 0.5 L ha^{-1} for controlling foliar pests, especially jassids. A foliar spray of Bravo fungicide was applied at 60 and 75 days after planting for the control of peanut rust and late leaf-spot diseases. A knapsack sprayer was used to apply these pesticides. Muriate of potash and triple superphosphate fertilisers were applied as side dressing 28 days after planting.

The field trial was laid out as a split-plot design with two (improved and local) practices as main plots, four varieties as subplots and replicated five times. The main plots were randomised in each replicate and the sub treatments (variety) were randomised within each main treatment. Plot sizes were not equal with replicates 1–3 having 12 m × 8 m plots (0.0072 ha final harvest area) while replicates 4 and 5 were 12 m × 6.4 m (0.0056 ha final harvest area).

Observations on the crop emergence and days to 50% flowering were recorded from the middle four rows in each plot starting from 21 March 2005. Farmers made a detailed recording of all activities carried out in the trial and Ramu Sugar scientists kept copies. The farmer also kept records of daily rainfall during the growing of the crop.

Results and discussion

Crop establishment was satisfactory in all plots. Subjective scoring for growth conditions showed that crops with improved practices had excellent growth compared to the local practice (Table 3). Significant differences (P<0.05) were observed between the practices. There were no interaction effects between practices and varieties used. But highly significant differences were observed for crop growth between the varieties. Variety ICGV 92160 had the lowest growth scores in both treatments. A highly significant correlation (r = 0.917, P<0.01, df = 6) was observed between growth score and yield (Figure 1). Plots with poor growth yielded lower than those with vigorous growth.

The improved practices resulted in significant improvement in crop growth (P<0.01) and yield (P<0.05) compared to local practice (Table 3). Yield differences between the varieties were not as large as they

Table 3. Summary of peanut yields, crop growth and foliar diseases assessments made in the on-farm trial at Umi Bridge, Markham Valley, Papua New Guinea (2005 season)

Practice	Variety	Pod yield (t/ha)	Growth score*	Disease score**
Local	ICGV 92160	1.32 d	6.4 d	3.4 bcd
	ICGV 94299	1.82 c	6.6 cd	5.2 a
	ICGV 94341	2.10 abc	7.4 bc	4.8 ab
	Yarang	2.08 abc	7.8 bc	3.6 bc
Improved	ICGV 92160	2.08 bc	8.8 ab	2.6 d
	ICGV 94299	2.56 a	9.6 a	3.2 cd
	ICGV 94341	2.64 a	9.6 a	3.2 cd
	Yarang	2.48 ab	9.4 ab	3.4 bcd
Mean		2.14	8.2	3.7 bc
LSD (P<0.05)		*P*<0.01	*P*<0.01	*P*<0.001
CV %		17.2	7.2	15.4

* Growth score, 1 = poor growth and 10 = excellent growth
** Disease score, 1 = healthy crop; 10 = dying crop due to foliar diseases.

were between the practices. With the improved practices, varieties ICGVs 94299 and 94341 gave the highest yields. With the local practice, the pod yields were highest in varieties ICGV 94341 and Yarang, while yields in ICGV 94299 and 92160 were significantly lower. Variety ICGV92160 was severely affected by leaf rust and late leaf spot disease which may have caused the lower yields observed under both treatments.

The yield response to improved practices for varieties ICGV 92160 and 94299 were highest (Figure 2) but the highest estimated profits were realised for varieties ICGV 94299 and 94341 valued at more than K3000 per ha (Table 4). The local variety (Yarang) responded least to improved practices indicating the best adaptation to the environment.

Disease incidence assessments were conducted only at 60 days after planting, using a visual scale of 1 (resistant) to 10 (highly susceptible) for foliar diseases. The main diseases encountered were late leaf spot and peanut rust. Although the disease situation in the improved practice treatments was generally better than the local practice plots, this was not statistically significant. There were highly significant (*P*<0.001) differences between the varieties for disease rating (Table 2) suggesting that foliar disease resistance is a key factor in selecting the improved varieties for on-farm trials.

A highly significant interaction (*P*<0.01) between practices and varieties was also observed, indicating that the varieties responded to disease management

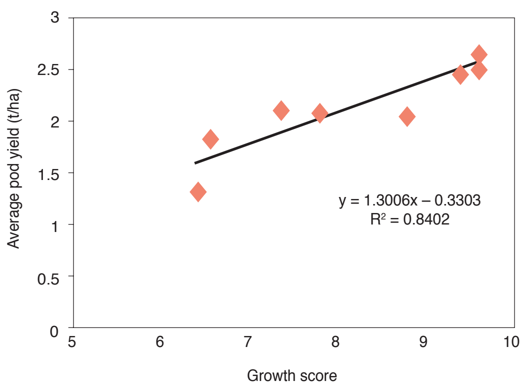

Figure 1. Relationship between peanut crop growth and pod yield from the seed village trial conducted at Umi Bridge, Markham Valley, Papua New Guinea (2005)

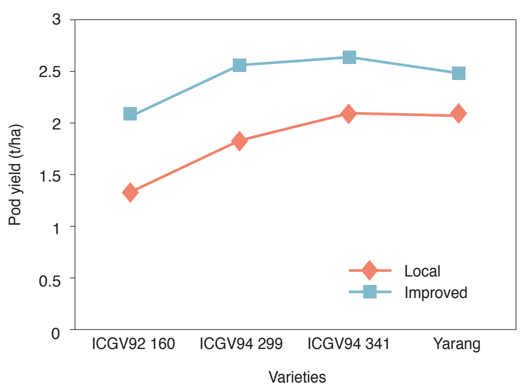

Figure 2. Comparison of peanut yields from improved and local practices in trials in the Markham Valley, Papua New Guinea

Table 4. Pod yields under local and improved practices from Umi Bridge, Markham Valley, Papua New Guinea seed village trial. Price of peanuts used for roadside sales was K60 per 30 kg bag.

Practice	Variety	Pod yield (t/ha)	Gross income (K)	Total cost (K)	Est. profit (K)
Local	ICGV 92160	1.32	2640	1165	1475
	ICGV 94299	1.82	3640	1240	2400
	ICGV 94341	2.10	4200	1282	2918
	Yarang	2.08	4160	1279	2881
Improved	ICGV 92160	2.08	4160	2002	2158
	ICGV 94299	2.56	5120	2074	3046
	ICGV 94341	2.64	5280	2086	3194
	Yarang	2.48	4960	2062	2898

(improved practices) with most responses observed in new varieties.

Foliar disease incidence was not severe in the varietal trials conducted at Ramu Sugar and thus did not warrant conscious selection for disease resistance. However, the foliar disease incidence was much more severe at the Umi Bridge site. The varieties used for evaluation were not highly tolerant to foliar diseases and hence required regular sprays. The take home message from the pilot seed village study was that a combination of high yield and foliar disease resistance (rather than yield alone) should be used as a criterion to select new varieties.

Some of the main issues identified in this trial that are worth considering in future trials are quality of seed-bed preparation, crop nutrition, crop husbandry practices and security of experimental plots. Tractors used by farmers are usually old and require regular maintenance. Land preparation is usually carried out with a 3–4 passes of disc plough. On new land, more than four passes are required to get the land ready for planting while the old/cultivated land might require only two passes. Even after several passes with the disc plough, the seed-bed may still need some manual or mechanical harrowing. However, there was no mechanical harrow available in the Umi area at the time the work was done. Costs of disc ploughing ranged from K300 to K1000 per ha per pass.

Most farmers use old blocks of land to grow peanuts without a fallow or in rotation with other crops. The site used for this trial has had peanuts in the last 2 seasons. Although there were no data on soil or foliar tests from the trial, severe nitrogen deficiency was obvious from the maize plants planted near the trial. Nitrogen deficiency was also observed in the local practice plots and this may be one of the reasons for poor growth in the crop. Since most soils in the Markham Valley have high P-fixation, it would be necessary to apply phosphorus as a basal treatment at planting. Therefore it is recommended that di-ammonium phosphate be used as a basal fertiliser at approximately 100 kg per ha. Future studies should also consider minor elements that may have an impact on crop growth and yields.

The local farmers do not plant in rows, so mechanical or herbicide weeding will be a problem. Plant populations are generally low thus increasing the frequency of hand weeding as well as reducing the yield potential. The ploughing of land using disc ploughs usually leaves a slightly raised bed which is important for drainage purposes. Security of the plots especially near harvest time will be important too.

A field day was organised two weeks before harvest for the farmers and other research and extension service providers to view the trial. More than 100 farmers attended this field day. Local farmers showed a lot of interest in the new varieties and the day resulted in fruitful interactions between researchers and extension service providers. A display by two local suppliers of agricultural materials also had a major influence on the local farmers. The study demonstrated that the seed village concept is a very good medium to extend peanut production technology and this should be considered in future trials.

Conclusions

The trials show that the new varieties and improved practices can contribute up to K3000 per ha profit to local farmers. The most productive varieties were ICGV 94299 and 94341 which produced over 2.5 t/ha of peanuts. Although these are attractive figures, further studies are to be conducted on disease resistant/ tolerant varieties and crop nutrition. These aspects are very important for sustainable peanut production in smallholder blocks especially in the Markham Valley.

Acknowledgments

The Australian Centre for International Agricultural Research (ACIAR) project ASEM 2001/055 provided funding for this work. We acknowledge technical guidance from ACIAR project leader Dr Rao C.N. Rachaputi and DPI&F principal agronomist, Dr Graeme Wright in designing and setting up protocols for the conduct of the trial. Anita Ape (farmer) provided land and other materials for the trial and Maria Linibi (service provider) assisted with all the negotiations and background preparations. Many research assistants, especially David Ekiha and Anton Anum of Ramu Sugar Ltd, assisted with the field work.

Reference

Holloway R.S., Zijsvelt M.F.W., Knight M.J., Brigatti J.M., Legger L., Strong B.W., Aland F.P., Blackburn K.J. and Holzknecht H.A. 1973. Land resources and agricultural potential of the Markham Valley. Research Bulletin No. 10 (Part 1). Department of Agriculture, Stock and Fisheries, Port Moresby. pp 220.

Productivity and marketing enhancement for peanut in Papua New Guinea and Australia: ACIAR project ASEM 2004/041 (January 2005 – June 2009)

Rao C.N. Rachaputi[1] and Ken Menz[2]

[1]*Department of Primary Industries and Fisheries, PO Box 23, Kingaroy, Queensland 4610, Australia; email: rao.rachaputi@dpi.qld.gov.au*

[2]*Australian Centre for International Agricultural Research, GPO Box 1571, Canberra, Australian Captial Territory 2601, Australia: email: menz@aciar.gov.au*

Background and justification

Peanut is an important crop in both Australia and Papua New Guinea (PNG). As a part of the ACIAR project on 'Improving yield and economic viability of peanut production in Papua New Guinea and Australia (ASEM 2001/55)', the critical role of peanuts in PNG farming systems was documented and high-yielding peanut germplasm lines from the International Crops Research Institute for the Semi-Arid Tropics were introduced and evaluated in multi-location trials in PNG. These trials resulted in identification of promising varieties with potential to yield up to 100% greater than the local varieties.

The next logical step is to transfer the new varietal and associated management technologies to smallholders and also to enhance the markets for, and marketability of, new peanut varieties in PNG. The Australian peanut industry has also highlighted a need to assess the potential for new markets for new peanut varieties and their products (i.e. especially high oleic acid peanut oil which is comparable to sunflower oil).

In Australia, spatial variability for yield and quality on broadacre farms is one of the major constraints to improving yield and profitability of commercial varieties. Recent work at the Queensland Department of Primary Industries and Fisheries (DPI&F) indicated that near infra-red reflectance (NIR) captured from aerial and satellite platforms can be effectively used to identify and monitor spatial variability (for disease, crop growth and maturity and aflatoxin risk) in peanut crops and to implement novel in-season management and harvesting strategies. The PNG National Agricultural Research Institute (NARI) and Ramu Sugar are also keen to apply this technology. In PNG, the application is more likely to be in terms of monitoring peanut crops (and other cropping systems), rather than intensive real time management, as is intended for Australia.

The objectives of the project are as follows:

1. Ensure multiplication and supply of seeds of new high-yielding peanut varieties to smallholders in Morobe and Eastern Highland provinces of PNG.
2. Demonstrate and monitor improved productivity of peanut using varietal, management, modelling technologies and a farmer participatory research approach in PNG.
3. Develop and apply aerial NIR remote sensing technology to monitor spatial variability and improve productivity of peanut in Australia and investigate the scope for applying the NIR technology to monitor peanut cropping systems in PNG.
4. Assess the potential of, and feasibility to enhance marketability of new peanut varieties and products in PNG and Australia.

Methodology

Multiplication of up to 15 of the most promising varieties identified in the precursor project will be undertaken at Ramu Sugar to achieve up to 2 tonnes of pods per variety. These varieties will be simultaneously evaluated and distributed via a farmer participatory 'seed village' concept. Associated new management practices will also be evaluated.

Application of satellite imagery will be explored to monitor peanut cropping in PNG and in Australia imagery research will focus on improving the real time management of peanut crops. The scope for improved peanut marketing as well as downstream processing will be assessed in PNG, while the market

Improving yield and economic viability of peanut production in Papua New Guinea and Australia
edited by Rao C.N. Rachaputi, Graeme Wright, Lastus Kuniata and A. Ramakrishna
ACIAR Proceedings No. 122
(printed version published in 2006)

feasibility studies in Australia will focus on the demand for various peanut oil quality characteristics embodied in recently developed high oleic acid varieties in light of human health and nutritional trends.

Coordination

The project will be implemented by DPI&F in collaboration with NARI, Ramu Sugar and Trukai Industries in the Morobe and Eastern Highlands provinces of PNG and the South Burnett District of Queensland in close consultation with ACIAR. The project coordinators of NARI (Dr Ramakrishna), Ramu Sugar (Dr Lastus Kuniata) and Trukai Industries (Mr Geoff Fahey), with assistance from their project staff and in consultation with DPI&F, will implement the project in Eastern Highlands Province, upper Markham Valley and lower Markham Valley, respectively. The local government agencies (Department of Agriculture and Livestock and Support Services Contract Facility) have an excellent network with a number of farmer groups and they are keen to collaborate and contribute to on-farm research activities in the project

Expected benefits

Papua New Guinea

- Sustainable seed multiplication and supply strategy to enable smallholders to access seeds of peanut varieties.
- Successful collaboration between public and private institutions and grower groups in demonstrating value of improved management practices using a farmer participatory approach to smallholders.
- Farmer participation in evaluating and choosing most appropriate variety and/or management practices to gain yield improvements.
- Human resource and capacity building through training on peanut crop monitoring, management and use of aerial remote sensing technologies in mapping peanut cropping areas, yield and production at a regional level.
- Implementation of strategic market feasibility studies to explore potential for new market opportunities for peanut and peanut value-added products and new avenues for investment in the peanut industry.

Australia

- Capacity building and further development and application of the remote sensing technologies for the benefit of the Australian peanut industry, with potential for spill-over benefits to a range of other crops.
- Peanut growers will be able to make appropriate in-season decisions about crop protection and harvesting management to minimise yield and quality losses due to spatial variability in their fields and thus achieve up to 20% greater profitability.
- Implementation of strategic feasibility studies to explore potential for production as well as new market opportunities for DPI&F's short-duration high oleic acid oil peanut varieties and their value-added products.
- In Australia, new markets and new short duration (<100 days to mature) peanut varieties with particular niche market characteristics may result in these varieties being grown beyond the traditional South Burnett region.

Impact

A significant community impact is anticipated in PNG and Australia within 5 years after completion of the project. The farmer participatory approach will provide smallholders with opportunities to evaluate and choose the most appropriate variety and/or management practices, leading to yield improvement. The major quantifiable impacts include about 40% increase in peanut production within Morobe and Eastern Highland provinces resulting in 4.5 m kina per year additional net income at current market prices, improved capacity in implementing farmer participatory on-farm trials, monitoring of aflatoxin risk and applying the remote sensing NIR technologies to monitor peanut crops in target regions. By applying aerial imagery-derived information, Australian peanut growers will be able to make appropriate in-season decisions about crop protection and harvest management to minimise yield and quality losses due to spatial variability and thus achieve up to 20% greater profitability. Feasibility studies on potential for new market opportunities in PNG and Australia will provide a sound basis for exploring new avenues for investment in the peanut industry.

Acknowledgments

The contribution of the project team members in DPI&F (Graeme Wright, Greg Mills, Yash Chauhan and Andrew Robson), Ramu Sugar (Lastus Kuniata), NARI (A. Ramakrishna and Alan Quatermain), Trukai Industries (Goeff Fahey and Humphrey Saese) in developing the project proposal is gratefully acknowledged. Thanks are due to DPI&F and ACIAR management for support and funding.